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## ROYAL AGRICULTURAL SOCIETY'S ENGINE TRIALS.

From "Engineering."

It is not a little curious that the only systematic trials of steam-engines conducted in this country should be carried out under the auspices of a society representing a branch of our industry, which has perhaps more recently than any other of even approximate importance availed itself of the aid of steam power. The reason, however, of this fact is sufficiently obvious. At the time that the Royal Agricultural Society of England was called into existence, agricultural implements were very crude affairs compared with those in use nowadays, and the makers of these implements were, as a rule, men who had little knowledge of true principles of construction. One of the duties of the Royal Agricultural Society was to improve this state of matters by the periodical examination of the various classes of agricultural machinery, and by the award of premiums for the best examples in each class; and when steam-engines—first fixed and subsequently portable—began to be employed by farmers, the Society naturally included them amongst the appliances to be subjected to competitive examination.

That these examinations, coupled with the extra competition between makers which inevitably springs from them, have on the whole been attended with highly satisfactory results, no one who is acquainted with the subject can fairly doubt; but we nevertheless consider that the time has arrived when a modification of the conditions under which the trials are carried out is greatly to be desired. The chief object of the competitive trials is, as we understand it, to do for the farmer that which he has no opportunity—even if he had the skill—to do accurately for himself, namely, to determine which is the best engine out of the variety submitted for examination. And by "best" engine we here mean that which is the best adapted for the farmer's use; not necessarily that which runs the greatest "mechanical time" with a given quantity of fuel, but that which under the conditions under which it will have to be employed will give its purchaser the best return on the money invested in it. A secondary object of the trials—and a very justifiable object too—is to reward those makers by whom the best engine is manufactured. Now, we do not hesitate to say that the regulations under which the Royal Agricultural Society engine trials are at present carried out are not such as to secure the attainment of the objects we have mentioned; and although we believe that in the majority of cases the prizes have been awarded to those makers justly entitled to them, yet this has been due, not to the efficiency of the rules, but simply to the fact that makers who have turned out best "racing" engines have rea-

ly ranked amongst the best makers of ordinary engines also. This, however, is not as it should be, and we therefore deem it advisable that in future trials other and more perfect regulations should be adopted. Before pointing out, however, the alterations which we consider to be desirable, it may be as well—for the benefit of those of our readers who are not conversant with them—that we should state briefly the principal features of the existing rules.

The engines which have so far been subjected by the Royal Agricultural Society to trials on the friction brake, may be divided into four classes, namely: 1st, fixed engines without boilers; 2nd, ordinary portable engines with single cylinders; 3rd, portable engines with double cylinders; and 4th, semi-fixed engines with boilers combined. These several classes we shall consider in the order in which we have mentioned them. First, then, with regard to the fixed engines without boilers. According to the Society's rules as adopted for the Oxford competition, these engines are not to exceed 10-horse power nominal, are not to have cylinders exceeding 11½ in. in diameter, and are to be worked with steam at 50 lbs. pressure, supplied from the Society's boiler, which is to be stoked by a man provided by the exhibitor whose engine is under trial. The load on the friction brake, also, is such that the engine, when running at its nominal speed, will just give out its nominal power, and the trial consists in ascertaining how long the engine can be kept running under these conditions on an allowance of 14 lbs. of coal per horse power. Now, the least consideration is required to show that these regulations are little better than absurd. In the first place, the employment of the erm "nominal power" is itself an absurdity; but inasmuch as it is still employed commercially, we may allow it to pass, notwithstanding its indefiniteness. Next, we have the limitation of the size of the cylinder, which is perfectly useless, as, so long as the power to be given off at the brake is not to exceed 10-horse power at the nominal speed of the engine, no maker at all acquainted with the action of a steam-engine would dream of employing a larger cylinder than he is compelled to do, in order to give his engine the appearance of being, commercially, a "ten-horse" engine. Next, we have to find fault with the steam pressure, which is too low, and the load, which is too light. At the time when the Society's engine trials were commenced, 50 lbs. per square in. was no doubt deemed a high pressure; but nowadays it is universally acknowledged to be considerably below that at which non-condensing engines can be economically worked, and in future trials the pressure should be raised certainly to 80 lbs., or still better, to 100 lbs. per square inch.

Then, again, the cases are extremely rare in which an engine rated commercially as a "ten horse" is worked at but ten-horse power. As a rule such an engine has to develop quite 15 or perhaps 20 actual horse power, and it is therefore an absurdity to test an engine with a load so greatly below that which it will have to develop in actual practice. Moreover, the practice of running the competing engines with such a light brake load is a direct inducement to the production of a class of engines possessing many peculiarities which are not merely not beneficial, but which are really objectionable in an engine intended for ordinary work. Thus a maker who desires to obtain a really successful result under the Royal Agricultural Society's conditions, must either construct an engine with a much smaller cylinder than is ordinarily provided with an engine rated commercially at the same nominal power, or he must employ the ordinary proportions and run the engine with a very low piston speed. If he does neither of these things he will have either to wiredraw the steam, or cut it off at such a point that it will expand below the pressure of the atmosphere before the end of the stroke is reached, both these being wasteful alternatives. But if the size of the cylinder is reduced below that usually employed in an engine rated commercially at the same power, there is an opportunity afforded for reducing the dimensions of other parts also, and the maker has every inducement to avail himself of this opportunity, and of the reduction in the friction which it enables him to effect, the result being a "racing" engine of inferior value to a purchaser. We know that there are makers, and very successful makers too, who although they reduce the size of the cylinder of their racing engines, yet provide

working parts with ample bearing surfaces, etc., for a much heavier load than those against which the engines are worked ; but the fact that these makers are conscientious enough to do this does not alter the fact that the conditions of the trials are such as to directly encourage an opposite practice.

Another point open to strong objection is the mode in which the performance of the engine is estimated. At present this duty is represented by the time which the engine will run with a certain allowance of coal, or, in other words, by the amount of coal used per horse power per hour. The duty thus estimated, however, is evidently dependent on three things besides the good or bad qualities of the engine, these being the quality of the fuel used, the evaporative power of the boiler, and the skill of the stoker. Inasmuch as the same boiler and the same quality of fuel are used throughout the trials, these two elements may not greatly affect the comparative results so long as the conditions of weather remain the same ; but with the skill of the stoker the matter is different. No one can admire thoroughly good stoking more than we do, but we, at the same time, have a strong objection to the testing of an engine being conducted in a manner which renders the result in a great measure dependent upon the skill of the man in whose charge the boiler is placed. The proper plan would be to allow each engine a given weight of water evaporated under a given pressure, or, in other words, a given weight of steam, and to estimate the performance of the engine by the weight of steam used per horse power per hour, instead of by the weight of fuel burnt. This plan would further have the advantage of rendering the results obtained on the trial field comparable with results obtained elsewhere, without introducing complications due to the evaporative powers of different boilers, and the relative skill with which they are managed.

Briefly stated, we consider that the conditions for testing the fixed engines at the Royal Agricultural Society's meetings should be somewhat as follows : First, that the term "nominal horse power" should be abolished, and that the competing engines should be merely required to develop a certain actual horse power—say 15-horse power on the brake ; secondly, that the pressureof steam used should be raised to 80 lbs., or 100 lbs. per square in. ; third, that no limitation should be placed upon the size of the cylinders, but that the makers should be at liberty to compete indifferently with small engines running fast or larger engines running more slowly, the sole condition in this respect being that they should do the full work during trial; fourth, that no engine should be allowed to run with a less clearance between the piston and the cylinder covers than would be allowable in regular work, and that the least clearance allowable in engines of different sizes should be clearly stated in the conditions of trial ; fifth, that special attention should be paid by the judges to the proportions of the working parts, the area of the wearing surfaces, and the provisions for lubrication ; sixth, that each engine should have all bearings, etc., well oiled before starting on its trial, and that it should receive no further lubrication until it had run at least two hours ; seventh, that the duty of the engine should be estimated from the weight of steam and not from the weight of fuel used ; and eighth, that no special appliances or "dodges" should be allowed to be employed during the run which could not be used in ordinary practice.

In the case of the portable engines tested by the Society, the practice at present is to limit the boiler pressure in the case of single cylinder engines to 50 lbs., and in the case of the double cylinder to 80 lbs. per square in., and to give to each engine brake load corresponding to 1-horse power for each 10 circular inches of piston area in the former case, and each 9 circular inches in the latter. The allowance of coal is 14 lbs. for each horse-power thus estimated, and the general conditions of the run are similar to those we have mentioned when speaking of the fixed engines, save that in the case of the portables, each engine is, of course, supplied with steam from its own boiler. In this case, where the engine and boiler have to be tested as a whole, it is undoubtedly difficult to get rid of that variable element, skill on the part of the stoker in charge, and in fact, the only way in which it can be overcome, so far as we can see, is to encourage each competitor to employ the very best man obtainable by making no allowance whatever for bad firing.

In the case of portables it would, we think, be advisable to abolish the existing

differences between the single and double cylinder engines, and to divide all the engines into three classes, according to the pressure of steam at which their boilers could be worked with safety. The limits of pressure for the three classes might be taken at 60 lbs., 90 lbs., and 120 lbs. per square inch respectively, this latter pressure being one at which steam cultivating engines are now often worked. As in the case of the fixed engines, we should propose that the classification by "nominal" power should be abolished, and that a certain scale of brake loads—say 10-horse, 15-horse, and 20-horse—should be determined upon, for either of which a competitor should be allowed to enter his engine irrespective of the size of cylinder of the latter, the only condition being, as in the case of the fixed engines, that the work should be done fairly, and that each engine should be tried on two different loads.

As in the portable engines it is the combined performance of the boiler and engine which has to be tested, it would be necessary to estimate the duty of the engine by the consumption of fuel as at present; but at the same time we think that the evaporative power of each boiler should be accurately ascertained and noted in the report on the trials. As regards clearance in cylinders and similar matters, the conditions we have given for the fixed engines might, we think, be adopted, and means should be taken to guard against the employment of unusually thin tubes, or fire-box plates, loose contracting ferrules, and other racing dodges which could not be advantageously employed in regular work. The present regulations requiring the tubes to be at least $2\frac{3}{4}$ in. in diameter and 1 in. apart, might, however, we think, be somewhat modified with advantage.

Of the semi-fixed engines it is unnecessary that we should speak at any length, as the regulations for their trial might, we think, be in the main identical with those adopted for the portable engines, some attention, however, being also paid to the floor area and cubic capacity of the space respectively occupied by the competing engines.

We have very far from exhausted the subject of agricultural engine testing; but we have endeavored to point out what we consider would be some desirable alterations in the Royal Agricultural Society's rules. Our object in proposing these modifications is to insure that the winning engine in such competition shall be more nearly a true representative of an engine that would give really good results in regular work than is likely to be the case under the present circumstances; and at the same time we desire to open the way for the employment of higher piston speeds and greater measures of expansion than the present conditions allow. In addition to noting the points we have mentioned, we consider, also, that the judges should have indicator diagrams taken from the engine whilst under trial, and the observations recorded should in fact be so complete that there should be no difficulty in discovering the true reason of the good or bad performances of any engine submitted for competition. At some future time we may have something further to say on this subject, but for the present we must conclude with a few remarks on some minor alterations in the mode of carrying out the tests, which we think would facilitate operations. As matters at present stand, the three brakes used by the Society have belt pulleys of slightly different sizes, and as no limitation is placed upon the size of the flywheels of the engines or on the speed at which they are driven, each brake load and the corresponding speed of the brake has to be calculated separately. These calculations are of course of a very simple character, but at the same time they involve no small amount of trouble and occupy time which can ill be spared. To avoid this trouble we should propose, 1st, that the radius at which the weight is hung on the brake should be such that the circumference of the corresponding circle should be 17.5 ft.; 2nd, that the weight of the scale pan on the brake strap should be counterbalanced; 3rd, that the brake speed should be fixed in all cases at 100 revolutions per minute; 4th, that all the brakes should have belt pulleys of equal diameter, say 50 in.; 5th, that each engine sent for trial should have a flywheel or belt pulley of a diameter (supposing the dimensions just mentioned to be adoped for the belt pulley on the brake) in inches equal to 5,000 divided by the nominal speed of the engine in revolutions per minute. Supposing these conditions to be adopted each 2 lbs. load placed on the

scale pan would represent a load corresponding to 1-horse power, and each 100 revolutions of the brake would represent one minute of "mechanical time," so that the latter would be obtained by simply pointing off the two right hand figures from the number indicated by the brake and counter.

## LECTURE ON TELEGRAPHY.

From "The Electric Telegraph and Railway Review"

The Rev. Arthur Rigg, M.A., delivered an entertaining and lucid lecture, at the Horological Institute, on "The mode of discovering the distance from the shore of a break in a Deep-Sea Telegraph Cable."

The lecturer commenced by explaining the great importance of being able to determine the whereabouts when a breakage occurs in a submarine telegraph cable, so that a vessel may be at once sent to the spot to pick up the cable, and effect the repairs. Otherwise it would be necessary to pick up a loop of the cable, and, passing it over a wheel inboard, underrun it to the great risk of again breaking it, to the broken places at an unknown distance. In the case of the Atlantic Cable it might be any distance from 1 mile to 3,000 miles.

The lecturer then stated that different metals possess different degrees of conductivity for electricity, and that as the conducting power became less the resistance to the passage of electricity from end to end of the metal was greater.

The following table will show the comparative conducticity possessed by seven different metals, beginning with silver as the best :—

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|---|---|
| Silver | 100 |
| Copper | 77.4 |
| Gold, fine | 55.2 |
| Iron | 14.4 |
| Platinum | 10.5 |
| German Silver | 7.7 |
| Mercury | 1.6 |

Wires of these metals required to conduct a given amount of electricity in the same time to the same distance would require the squares of their diameters, or the areas of their sections, to be in an inverse proportion to their conductivity. For instance, a German silver wire, to conduct the same amount of electricity with the same resistance as one of pure silver, must contain 13 times as much metal in the same length, or in other words must form a wire containing the bulk of 13 wires of pure silver.

For the same material, the amount of resistance offered to the passage of the electric current is in an inverse ratio to the size of the wire. Thus, if a pound of wire be only one yard in length, the resistance offered to the current will be 1,760 times less than the resistance offered by the same weight of wire drawn to the length of a mile.

Having thus prepared his audience by preliminary information of this nature, the lecturer proceeded to explain the construction of the instruments used in the course of the lecture ; first, the resistance coils, which instrument is constructed to show the resistance up to 999 ohmads or British Association units of electrical resistance, asking the audience should he call them by that name or call them pounds ? It was decided to call them pounds ; so that when comparative numbers as to resistance occur, they will be termed pounds. This instrument is composed of a quantity of German silver wire of different sizes, coiled on bobbins, so placed that a current of electricity can be sent through one or more at the same time. This is effected by an arrangement which was shown on the top of the box containing the coils of wire, and was described by the lecturer as a group of islets surrounding a large island, and separated from it and from each other, but could be connected by means of a brass plug, or bridge, and in accordance with the position of this plug was the amount of resistance increased or lessened in decimal ratio, as units, tens, hundreds, etc.

The next portion of the apparatus was the Wheatstone-bridge, invented by Sir C. Wheatstone, by means of which a current of electricity may be split, one portion of the current (or, as in the language of the leturer, electrical passengers,) going in one direction, through the cable to be tested, the other passing through the resistance coils as the means of ascertaining the amount of resistance, both portions finding their way back to the battery. This was very clearly illustrated by

some well-executed diagrams showing the whole of the two routes of the electrical passengers from the battery, the one route through the cable and earth, the other route through the resistance instruments,—both routes ending in the battery. The reflecting galvanometer invented by Sir William Thomson was next described. Its construction is exceedingly simple, being merely a small astatic combination of two magnetic needles suspended by a single fibre of natural silk. Attached to the needles is a small mirror. One needle is surrounded by a coil of copper wire covered with silk. A lamp was so placed as to throw a streak of light through a slit on to the mirror, whence it was reflected to a long strip of paper divided equally like a rule. By this arrangement the slighest motion of the mirror was increased in direct proportion to its radial distance from the scale. This instrument is so exceedingly sensitive that the lecturer said, it was possible to waft a kiss across the Atlantic Ocean : in illustration he showed a sensible deflection of the needle by merely placing on the tongue a threepenny piece and a small piece of zinc, and sending a galvanic current through the 999 units of resistance to the galvanometer. The reporter has himself seen the same effect produced by the same means through the whole length of the Atlantic cable on board the Great Eastern.

With these instruments and a small battery composed of zinc and copper, in a vessel no larger than a wine glass containing a solution of common salt, the lecturer proceeded to demonstrate the practicability of discovering the locality of a break in a submarine cable. Having attached his battery and connected the several wires to their proper terminals, the lecturer showed the use of the resistance coils by moving the plugs into various positions. The result was shown by the motion of the streak of light on the divided scale. The course of the electric current and the use of the earth plates were then explained by means of diagrams showing that a plate of copper buried in the earth and connected by a wire to one pole of a galvanic battery, the opposite pole being connected with one end of a submarine cable, crossing the Atlantic or other ocean, and then connected with a similar plate of copper buried also in the earth, the electric circle is completed through the earth at whatever distance it may be. By inserting the necessary indicators and other apparatus, at the various stations, messages can be transmitted.

If the cable should be broken or so injured that the conducting wire is exposed to the water, that is termed "making earth," and the signals, instead of passing to the other side, return through the earth to the home plate, thence to the battery from whence they started. Prior to the discovery of the earth circuit by Steinheil about the year 1847, whenever a telegraph line was constructed, two wires were placed the whole distance in order to complete the circuit, thus doubling the cost.

The lecturer next proceeded to show the method of discovering the distance of the fracture from the shore ; and, as he could not demonstrate it by means of an actual cable, some bobbins of fine wire were made to represent one, in addition to which about 300 yards of fine iron wire were wound about the room. By attaching the two ends of that wire in two binding screws of the Wheatstone-bridge and connecting the little wine glass battery of salt and water also to the bridge, the whole of the current would pass through the wire or cable to the battery. By connecting the resistance coils to the other side of the Wheatstone-bridge the two routes were completed and the electrical passengers were started on their journey, the object being to discover what amount of resistance they would meet with and where, opposing their return to the spot whence they started and to which they were seeking the easiest route, for back they must come.

The circuit being complete, if the resistance offered by the cable (as the lecturer called the fine iron wire before mentioned) be greater than that offered by the resistance coils, the streak of light will move in one direction, and if less it would be deflected in the opposite direction, and by shifting the brass plugs, connecting the islets with the island, till the resistance each way is equal, the streak of light rests at zero, in the centre of the scale. In this instance the resistance was 70 units, and as that is equal to about $4\frac{3}{4}$ miles of copper wire of No. 16 gauge the length of the wire would have been $4\frac{3}{4}$ miles, or the broken place would be $4\frac{3}{4}$ miles from the shore. To carry it still further, if we assume the 70 units to mean 70 miles, then

the break would be found 70 miles from the shore. This may perhaps be made plainer to non-professional readers in this way :— There are 100 electrical passengers to start on a journey and an arrangement is made by which two ways are open, and they start 50 each way; arriving at a certain point on one route, there is a resistance to their passing and only 25 can get through, the remainder turn back and take to the other or easier route. To enter upon this route they must pass through the wire of the galvanometer. In doing so the little speck of light is caused to move; and thus, as by a pointer on the scale-beam, is indicated the direction in which these electrical passengers are travelling, and therefore on which side the greatest resistance to their passage is found. The same experiment was shown through two bobbins of fine wire, in which the resistance was equal to 500 units, equal to 33½ miles of No. 16 copper wire; so that in a cable composed of such wire the injury would be 33½ miles from the shore.

A very novel and simple battery was then shown, being two small ribbons of metal, each ¼ in. wide and 3 in. long, one zinc and the other copper, stuck into a potato. Attaching the wires to the resistance coils and the galvanometer, very sensible deflections of the needle were produced through the whole 999 units of electrical resistance. It is obvious by comparison that the same effect would have been produced through a telegraph line composed of 66 miles of copper wire of No. 16 gauge. In conclusion, the lecturer stated that he believed many of the phenomena of electricity were still hidden, and it may fall to the lot of some now living to see this agent used as a motive power in the place of steam, and as heat in the place of fuel, and as light in the place of gas.

## BRONZE GUNS.

From "The Engineer."

The recent introduction of a bronze muzzle-loading field gun for the Indian artillery by General Wilmot's committee, and the possible adoption of the same class of weapon for the English artillery generally, has given an importance to the experiments now in progress in Belgium with bronze guns, which a few years ago they would hardly have possessed. It is a significant fact that there are assembled at Liége at this moment artillery officers from nearly every European nation—including our own—for the purpose of watching experiments with bronze guns. A few years ago this would have been impossible. The nations seemed to be gradually settling down with their steel or wrought-iron field guns, or with systems less costly and less efficient; and among things of the past might, except in a few rare instances—as in France—be ranked bronze field guns. Those which existed were for the most part in process of supersession. But the tide has lately turned—for our country, at least, it has done so—and elsewhere experiments have been for some time in progress, the object of which is the application of bronze to rifled guns. Every one knows the merits and defects of that material for cannon. Its conspicuous merit is its toughness and resistance to explosive bursting. Whatever a bronze gun may do, and however it will fail, it will assuredly not burst explosively like steel or cast-iron. The metal has other advantages, not the least among which is its adaptability for conversion. When your bronze gun is worn out, or when the pattern is superseded, you have always so much valuable metal which can be sold or recast. And the lightness of the metal is a further recommendation in the eyes of the artillerist. But for rifled guns bronze has always been supposed to possess certain important disadvantages—chief among which is its softness and liability to injury by the friction of the studs, or the mechanical action of the powder gas. Until General Wilmot's committee proved that it was otherwise, experienced men declared that no bronze gun could long stand the destructive action of a rifled projectile. It was known that the French guns wore out with a rapidity which might be inconvenient on a campaign. But the committee which we have named proved that by adopting a narrower groove, and by care-

fully adjusting the height of the studs in relation to the groove, a bronze gun might be made to endure a vast amount of firing without becoming unserviceable. Two guns have, at the hands of the committee, endured respectively 2,673 and 1,362 rounds with charges relatively higher than those of any other rifled gun in Europe, and still remain perfectly serviceable. These figures, translated into plain English, mean a life of 53 and 27 years' ordinary service. It is clear, therefore, that bronze may be perfectly serviceable for rifled field guns. On the other hand, it was urged that these results could only be obtained by adopting very soft metal for the studs. But, as General Wilmot's committee observes, "when put to the test of experiment this objection is found to be completely without foundation. The zinc studs are but little liable to injury by the rough treatment. Nothing short of intentional injury can render the projectiles thus studded unserviceable." As to the scoring of the grooves, from which much was feared, the practice is not thereby materially affected, the scoring being confined to the loading side and bottom of the bore. Further, when shells were burst by the committee within the gun, the serviceability of the weapon was not interfered with. But, for all that, it is evident that if bronze can be made at once harder, more resisting, and more elastic, it will be, *pro tanto*, a superior metal for artillery purposes. There is more than one direction in which it may be possible to work with advantage. There is first the direction of chill-casting; secondly, that of casting under pressure; thirdly, that of hardening the alloy. It is with the first and third of these expedients that the Belgian experiments connect themselves. Messrs. Montefiori-Levi and Kimtzell, nickel manufacturers, of Val-Benoit, near Liége, have for several years been experimenting with bronze. They have lately conducted a series of systematic experiments with bronze hardened in various ways. They found that by casting ordinary bronze in chills its hardness and tensile strength were greatly increased. By alloying a small proportion of phosphorus with it they found that an immense augmentation of strength and hardness was the result. After satisfying themselves by various tests—conducted chiefly by Mr. Kirkaldy—that phosphoric bronze cast in chill is, as far as the resistance to statical pressure and strain is concerned, vastly superior to ordinary bronze, however cast, they deemed it worth while to institute, under the auspices of the Belgian Government, a series of gunnery experiments with the new metal. Perhaps "new metal" is hardly the correct expression to use, and its employment without qualification may provoke discussion. Phosphoric bronze has long been known, and, to a certain extent, employed in this country. In 1861 experiments were made with it in the Royal Gun Factories at Woolwich. Dr. Percy, in his work on "Metallurgy," treats of it. Professor Abel has written one or more treatises on the subject. Mr. Forbes, of Birmingham, has employed it, and perhaps does so still—we believe that he even took out a patent for the metal—and elsewhere phosphoric bronze has been experimentally employed. But until the present time no formal and systematic experiments have been made, or perhaps, we should say, no experiments so formal and systematic as those conducted by Messrs. Montefiori-Levi and Kimtzel, and now in their final stage of progress in Belgium, have ever been carried out. To detail the results of the statical and other experiments on the new bronze would occupy more space than we can afford to the subject. It will be sufficient to state briefly what is now being done. Two guns have been cast—small smooth-bore muzzle-loaders—one of the ordinary and one of the phosphoric bronze, the latter having been cast in chill. These guns are being tested for hardness, for resistance, for non-liability to corrosion. The experiments—which are being carried out at Liége by the Belgian officials, in the presence, as we have stated, of representatives from nearly all the European nations—will probably continue throughout the present month. Thus far, we are informed, the new metal has established a great superiority. But the tests thus far applied have only gone so far as to measure the relative hardness of the two cannons. That the new bronze is far harder than the other is fully proved. It remains to be seen if it is equally resisting to the explosive and mechanically destructive effects of gunpowder. To prove this the tests will be pushed *à l'outrance;* and further, a breech-loading

rifled gun of phosphoric bronze will be tried, to determine the suitability of the metal for pieces of this description. The direction in which the new metal appears most likely to fail, if at all, is in its susceptibility to be burnt or eaten into by the powder. This is inferred from the fact that a breech-loading small-arm, of which the breech was made of phosphoric bronze, showed signs of deterioration after a few cartridges, made purposely defective, had been fired in it. The gun now under trial, we are informed, has not exhibited any symptoms of failure of this sort. It is, therefore, too early to express any decided opinion upon the subject. We hope, as the experiments progress, to be able to keep our readers informed as to the results, which are exciting a good deal of interest. It should be mentioned that an important advantage obtained by the use of the new bronze is the remarkable homogeneity and conformity of the casting, and the absence of any necessity for casting with a "dead head." Those who are familiar with the operations of bronze casting will be able to appreciate these advantages, quite independently of any merits which the new metal may possess for artillery purposes. The phosphoric bronze gun now being tried at Liége was cast without any dead head at all; it was cast also by inexperienced men, with rude appliances, in a nickel factory, and yet it has already worn out one gun of ordinary bronze which was opposed to it, and is still, we are informed, quite serviceable.

## SWEDISH RAILWAYS.

From "Engineering."

This commnication suggests some considerations of great practical interest not only to Sweden, but also to our own country. From the information thus furnished we may conclude that in Sweden, as indeed in many other countries, the mistake has been committed of adhering to one particular system of railways, copied from England or from some part of the Continent, without paying due regard to the differences in the physical and social condition of the two countries, such as the sparseness of population, the small amount of traffic, and the limited means at the disposal of the nation for further construction; and although we have no fault to find with the construction as far as it has hitherto been carried out, it must be admitted that the delay in completing the entire system of railways must have greatly hindered the development of the resources of the country. But as industrial speculation has increased, the railway fever has now again become rife in Sweden, and there is naturally a voice of warning raised against the extravagance of continuing the old expensive system of railways. This has consequently led to a contest between politicians and engineers, the men who grant the money and those who spend it. The contest has, however, been nobly conducted, and free from personalities, while both sides of the question have been fairly enough argued. In pronouncing a decision in the case we think that it requires but little consideration to declare in favor of the Government, who propose to complete the system with the 4 ft. 8½ in. gauge, but with light rolling stock, using, however, for branch lines the 3 ft. 6 in. gauge.

Similar questions are now in agitation with respect to the extension of railways in Russia, India, and Canada. Two 3 ft. 6 in. lines are being experimentally constructed in Russia, the one by the Government, and the other by private capitalists. Should this experiment be successful it will decide the adoption of that gauge for the extensive system of branch lines required in that vast empire. While many countries are thus in a state of indecision on this subject, Norway finds herself free from this difficulty, thanks to her engineer, Carl Pihl. For as we mentioned some time ago, the main lines in Norway are chiefly laid with the 3 ft. 6 in. gauge.

Norway, indeed, is the only country where the narrow gauge system of railways has been efficiently carried out, for there the old school of costly construction was quickly superseded by a more advanced system, in which the adaptability was the one first consideration. Mr. Pihl may be fairly considered the apostle

of this new school, for in no other country have cheap railways been adopted as a standard, and even in those places which we have already quoted as having introduced, or which are now introducing, narrow gauge lines, the distance which the rails are placed apart appears to be the ruling consideration, whereas, in reality, this is but one of the many items that go to make up the total of cheap railway construction. Benefiting by the experience in the sister country, Sweden has to a limited extent availed itself of the results of Mr. Pihl's work, and 3 ft. 6 in. gauge railways have been in operation there for some time. But the standard gauge, nevertheless, is the ordinary one of 4 ft. 8½ in., and the whole of the prolonged discussion ostensibly relates to the question whether it is advisable to complete the main railway system of the country to the standard width, or whether it would be preferable to adopt a cheaper construction and a narrower gauge for the comparatively short length yet remaining to complete the system of main lines.

It is difficult to imagine so protracted a discussion upon so simple a problem as the one immediately involved, and it is therefore only fair to consider that it bears reference to the general rather than the special question.

Doubtless it is a grave error to establish an extravagant system of railway construction, but once adopted and developed to a large extent, the error would be more serious to make a broken gauge, and the first outlay that would be economized would be speedily swallowed up in the various expenses which would be incurred, to say nothing of the various and constant inconveniences imseparable from such a change. Mr. Elworth, an engineer upon the Swedish Government railway staff, and one of the chief champions of the uniformity of gauge, takes unnecessary pains to establish his case, and advances figures which are based upon somewhat obscure data, to prove that a saving only of £477 a mile would be effected by building to the 3 ft. 6 in. instead of 4 ft. 8½ in. gauge. And this saving he proceeds to demonstrate would speedily be consumed for the separate rolling stock required, the independent shops, and engine and carriage sheds, the distinct management, and the cost of shifting loads from the line of one gauge to that of another, and a loss altogether of more than £25,000 on the proposed extension would be the result. Without caring further to inquire into calculations which cannot be considered fair, we need only consider the question of expedience with regard to breaking the gauge in the main system of Swedish railways, and every argument tells against the advocates of these views Mr. Elworth opposes. The narrow gauge railways of Norway are amply sufficent for the traffic requirements of that country, and will continue to be so, till the uncertain future shall have brought with it largely increased demands, when further expenditure for additional accommodation will be justifiable. And equally so with Sweden ; but as its railway system was established before the days of narrow gauge lines, there remains nothing for it but to continue them of the same width. But not in the same manner, and taking example by Mr. Pihl, the Swedish engineer before alluded to, he addresses himself in the right way to the task of making the best of existing circumstances. He knows that a 4 ft. 8½ in. gauge does not necessarily involve a great outlay in original construction, and he very clearly demonstrates that by the adoption of light rails, of minimum formation width, of cheap stations, in fact, of all the elements which together compose a cheap railway, whatever may be its gauge, the standard system may be kept intact, the outlay may be kept down, and that Sweden may complete the Upsala-Storvik line with no fear for the result.

With the secondary system, however, matters stand very differently, and the advocates of the 4 ft. 8½ in. gauge could scarcely hold their ground. For the most part these lines would have a purely local importance, effecting no junction with the main railways, and, as a rule, they would be built as a development of the mineral wealth of the country, which must be idle and useless until means are provided for its transport. We have already stated that Sweden abounds in rich iron ores, and that she could—the means of transportation being provided—place an unlimited quantity at low prices at the disposal of our steel manufacturers.

To effect this a number of cheap independent railways would be required, connecting the mines with the coast, and it

is toward the construction of these that public attention is being specially directed in Sweden. For they are more important than the completion of the State main railways, seeing that the future commercial prosperity of the country is dependent upon its mineral wealth and upon that alone. Sweden cannot ever become the seat of a large iron manufacture, for the cost of fuel forbids such a result; and it only remains, therefore, for her to transport her ores to a market where they will find an inexhaustible demand, and which would at once confer prosperity upon herself and lend invaluable aid to the industry which year by year must assume larger proportions—the manufacture of Bessemer steel.

Diverging, therefore, from the comparatively unimportant question of gauge for the State railway shortly to be set in hand, the great discussion which even now is earnestly going on in Sweden, is embracing the general question, and while at the same time that private enterprise to serve private ends is energetic in its efforts to promote the wealth of the country, the Government has before it a higher and a more comprehensive duty, in stimulating and assisting those endeavors. The great importance of action is acknowledged, the means to be taken are no longer problematical, and Sweden has for her nearest neighbor a country from which she can gain experience, and whose railway system is even at the present time being officially inspected with reference to its adoption in India, where cheap narrow gauge railways are now acknowledged to be all-important.

## ON A NEW APPARATUS FOR REDUCING CHLORIDE OF SILVER.

By A. LIEBIUS, Ph. D., Assayer to the Sydney Branch of the Royal Mint.

[From "The Artizan."

In the refinage of gold bullion by Miller's new chlorine process, the silver contained in the alloy thus treated is eliminated from the latter in the state of argentic chloride, which, by a subsequent process, is reduced to metallic silver.

This reduction has always been effected in the usual manner, viz., by placing the slabs of fused argentic chloride between plates of wrought iron or zinc, with the addition of acidulated water. Although a perfect reduction to metallic silver has always been achieved, yet it required a considerable amount of time and manipulation, since the thick slabs of fused argentic chloride were, after two or three days, only partially converted into metallic silver, and had to be re-arranged in order to expedite their complete reduction. Such manipulations, however, were not only found to be very objectionable on account of the time they required, but more so on account of the very disagreeable work which they caused to the operator. The reduced spongy silver was broken up by hand into small pieces, in order to ascertain its complete reduction, and was then boiled in acidulated water to free it from iron or zinc.

It remained, therefore, a desideratum to effect the reduction of the fused masses of argentic chloride in a manner which would, at the same time, be quicker in its execution, and also obviate the just-alluded-to manipulations.

In 1868, Messrs. De la Rue and Hugo Müller, in London, constructed a galvanic battery, one pole of which consisted of fused argentic chloride the thickness of a goose quill, the other pole of cylinders of zinc. Adopting this principle, I have endeavored to construct an apparatus which should fulfil the requirements before referred to.

After operating successfully with a small model which allows the reduction of about 250 oz. of argentic chloride in one operation, I have, with slight modifications constructed an apparatus which will reduce from 1,400 to 1,500 oz. of argentic chloride in twenty-four hours. The apparatus and its dimensions are as follows :—

Two thick boards, 15 in. long, are joined together on both ends by three strong battens, so as to form an open box without a bottom, 13 in. long by 14 in. wide, and 15 in. h gh (inside measurement). The two boards forming the length of the box or frame contain seven vertical

grooves, ½ in. wide, and ½ in. deep, at intervals of 1½ in. from each other. These grooves are cut down to a length of 12 in., leaving 3 in. of each board forming the legs of the frame.

At the termination of these grooves passes horizontally a narrow slit, ½ in. deep, and along the whole length of each board, into which a strip of metallic silver, ½ in. wide and the thickness of a threepenny-piece, is tightly fixed, projecting on one side of the frame about 18 in. beyond each board.

The seven grooves already alluded to are for holding zinc plates, ½ in. thick, 14 in. long, and 12 in. high, which rest on both sides on the strips of silver, which, as just described, are jammed horizontally into the sides of the two boards. A connection is thus established between the seven zinc plates and the strips of silver.

The second part of the apparatus consists of a wooden frame, cut out of a solid board 1 in. thick, and supplied with two large iron handles. This frame is the same length as the box holding the zinc plates, but 3 in. narrower. It contains on each side, parallel to the direction of the zinc plates, 12 slits ½ in. long, which hold silver bands ½ in. broad and the thickness of a threepenny-piece. These silver bands are passed through the slits in the board, so as to form on each side of it six loops, 11½ in. in length and ⅞ in. wide. The six loops on one side are exactly opposite to those on the other side of the board, at a distance of about 9 in. They are intended to hold the slabs of argentic chloride, which are 12 in. long, 10 in. high, and about ¾ in. thick, and are put through these loops lengthwise, projecting on each end about 1 in. beyond the silver bands.

The whole frame holds, as before stated, six of these slabs of argentic chloride, which are placed between the six spaces formed by the 7 zinc plates, from which latter they are about ½ in apart on each side.

The projecting horizontal strips of silver jammed into the sides of the lower frame are then connected with the ends of the silver forming the loops in which the argentic chloride is suspended, and the whole apparatus thus charged is placed in a tub filled with water. After a short time galvanic action is discernible; the liquid gets gradually warmer, and a strong galvanic current is observed. After about 24 hours the action has nearly ceased, and the whole argentic chloride is found to be completely reduced to metallic silver, which retains in the silver loops the same shape, and, outwardly, also nearly the same appearance as when first introduced as argentic chloride. The latter contains always more or less chloride of copper, eliminated together with the silver during the operation of refining by chlorine, which is reduced together with the chloride of silver; in fact, this soluble chloride of copper helps to act as an exciting liquor for the battery. In the first experiments, a weak solution of salt (chloride of sodium) was used as exciting liquor; but it was found that this could be dispensed with, and only common water used. The action, however, is in this case a little retarded, and does not become powerful until about two hours after the battery is set. By using a part of the resulting liquor from a previous reduction of argentic chloride and which contains chloride of zinc, it has been found that the galvanic action sets in very rapidly, and accelerates thereby the completion of the reduction.

No acid is used, and therefore the amount of zinc used in each reduction has invariably been found to be almost the theoretical quantity required to combine the chlorine of the argentic chloride treated with the metallic zinc, in order to form chloride of zinc

The quantity of metallic zinc thus used was always from 24 to 25 per cent. of the weight of the argentic chloride reduced.

The reduced silver is boiled out in acidulated water, in order to remove the basic oxy-chlorides, and finally in pure water, while still suspended in the silver loops. As soon as it is taken off the last boiling, it is immediately ready for the melting pot, since the heat from the boiling water dries the porous mass of silver sufficiently to allow of its immediate melting. The seven zinc plates, when first used, weigh about 140 lbs. avoirdupois; the six slabs of argentic chloride, of the dimensions already given, weigh about 1,400 oz. troy.

The zinc plates are used over again, until too thin for that purpose, when they are re-melted, and cast into new plates. It has been found that the quantity of zinc

used is little, if at all, increased by prolonging the time of connection with the silver plates after the reduction is completed; the whole apparatus when once set in operation, can therefore be left to itself until it is found convenient to melt the reduced silver.

While this apparatus reduces the argentic chloride much quicker than if the latter is simply placed in contact with zinc or iron plates, it obviates any handling of the argentic chloride from the time the latter has been placed in the silver loops until the reduced silver is ready for the melting pot—advantages which have been fully appreciated by those who formerly had to resort to tedious and disagreeable manipulations.

## NATURAL AND ARTIFICIAL PRODUCTIONS OF CHINA.

From "The Mechanics' Magazine."

Notwithstanding that the united French and English armies have penetrated to Pekin, and that the plenipotentiaries of both countries maintain their court in that distant capital, very little is really known of the resources, the industries, and the natural wealth of the once famous land of Cathay. Some of our own countrymen have given us much information respecting this ancient country, and recently M. Stanislas Julien and M. Paul Champion have published a work reviewing the whole subject, which is full of interest and not altogether void of instruction. Some day or other that vast empire must acknowledge the power of steam, and substitute railways for its present canals; and it is worth while to briefly notice what return it can make, what guarantee it can offer, for the investment of capital on large and extensive works. Among its mineral resources the Flowery Land can number the precious metals as well as those of the baser description. Gold is found native; also associated with iron pyrites, as occurs in Brazil and in the beds of some of the rivers. The river King-cha kiang fully deserves the classic epithet "flavis." It rises in the distant mountains of Thibet, and, after a circuitous route, "pours down its golden sand" in the province of Yun-nan. With the exception of the washing process, the Chinese appear to be ignorant of the art of extracting gold from any matrix with which it may be associated. They distinguish the different qualities by their color, and class them accordingly. Thus the red, which is chemically nearly pure gold, is designated by the number ten; the yellow by eight, and the greenish by seven or seven and a-half. For testing gold they still have no other method than the old and somewhat uncertain touchstone. The suspected specimen is rubbed with the stone, and then placed in contact with some warm sulphur. If pure, it preserves its color, but if it becomes tarnished it is owing to the presence of silver or copper. This test is both imperfect and ambiguous. As frequently happens in Oriental countries, silver is more plentiful than gold in the Celestial Empire; and the working of the mines is an Imperial privilege, only conceded at the price of a heavy royalty. A Government agent assays the metal and fixes the price to be paid for the concession, which is roughly proportionate to the intrinsic value of the ore. The silver is found in various combinations with other metals. Thus there is the argentiferous galena, a common ore in most countries; also silver in combination with copper, antimony, sulphur, and arsenic. The methods of extraction closely resemble those practised by ourselves, and the metal is procured in a state of tolerable purity. From the south-western provinces of China comes the whole of the tin used in the country. It is classified under the two divisions of mountain, and river or stream tin, the latter of which is the purer and the more esteemed. As an alloy the Chinese fully understand the value of this metal, and render it malleable by the addition of a certain quantity of lead, a process which is carried to an extent that often leads to frauds upon the inexperienced.

M. Champion states that in a work consulted by him, bearing the date 1637, there was no mention made of zinc, or Japanese lead, as it is called. It is therefore presumable that the metal was not known anterior to that period. It is much valued for its alloying powers, and

Canton boasts of supplying the substance in its greatest purity. There is one application of arsenic in vogue among the Celestials which deserves notice. Through its means the young and tender roots of plants are preserved from the attacks of field mice and other vermin, and it not only protects them also from damp and insects, but exercises a favorable influence upon the growth of the plant and the yield of the crop. It is recorded in "The Book of Mountains and Seas" that copper, either native or as an ore, exists abundantly in 437 mountains throughout the empire, and principally in those situated towards the East. The sources being so abundant, it is but natural that the different ores should be equally numerous. There is nothing worth recording respecting the Chinese treatment or employment of this well-known metal, unless it be the alloy, of which their barbarous gongs or tam-tams are constructed; 24 parts of copper and 20 parts of tin compose the mixture which imparts to them their peculiarly disagreeable properties. We recommend the proportions to those gentlemen who are racking their brains to produce some novel noises for the next pantomimes. It should perhaps be mentioned that the beautiful azurite and the mottled malachite are among the varieties found in the manifold mountains. With the exception of the extreme primitive nature of the tools and appliances used in the smelting, casting, manufacture, and subsequent conversion of the raw material into wrought iron and steel, the principle of the various processes is nearly identical with that prevailing among ourselves to within the last 15 or 20 years. The best steel is made from the magnetic oxide, which is tolerably abundant in some parts of the empire. It is well known that the superiority of the Swedish metal is due to the same cause, possibly enhanced by the use of wood for the fuel. In the manufacture of mirrors, the Chinese follow the method handed down from the year 700 A. C. These ornaments, both in China and Japan, are formed of a metallic plate having the composition of copper 50.8 parts; tin, 18.5; zinc, 30.5; and lead 2.2; the total making up a hundred parts. After being brought to a high state of reflective brilliancy, the surface is covered with an amalgam of tin, lead, and mercury in the respective proportions in a hundred parts of 69.36, 0.64, and 30.00. These mirrors lose their polish in a few months, especially if exposed to any sulphurous emanations, but can be easily repolished at a trifling cost. Among natural curiosities may be mentioned the tallow tree, which furnishes by the bruising of its fruit a limpid oil of considerable purity. Th manner in which the Celestials turn out their candles is amusing, and decidedly ingenious. The everlasting bamboo is, as usual, in requisition. One of them is split longitudinally, the pith extracted, a wick placed in the hollow, and the two halves then tied together with strips of osier. A cylindrical mould is thus obtained, into which a quantity of melted tallow, procured from the tree of that name, is poured. So soon as it is quite cold, the two halves of the divided bamboo are again separated, and *la chandelle est fabriquée*. To prevent the candle sticking to the mould, the latter is well moistened by a short immersion in water.

One of the most widely known and extensively used products of Celestial manufacture is unquestionably that of the celebrated Indian ink, or, as it should be correctly called, "*encre de chine*." Had we the space to spare we would willingly describe the process in detail, but must content ourselves with observing that the real secret of the art lies in the preparation of the lampblack, which forms the principal component. So famed are the Chinese for their lampblack that, although their island neighbors, the Japanese, manufacture the same article, yet they yield the palm to the former, and the richer class among them never use their own home-made ink, but import it from the main land. The author mentions several tests for distinguishing Indian or Chinese ink of a superior quality from that which is inferior; some of these are known to most of our professional readers, but there are one or two which are rather novel. Thus it is not generally known that a stick of good Indian ink may be known by its sound, when struck gently on a hard body. If it be of good quality, the sound will be clear, with a slight ring in it. On the contrary, if the sound be flat and dull, it is a sign that the composition is not homogeneous, and the quality inferior. Like wine, the older the ink the better, and the best is always the heaviest. There are some pieces existing in the

Emperor's palaces which may be truly said to have been preserved from time immemorial, the date of their manufacture having been lost in the oblivion of past ages.

In a matter so nationally important as that of agriculture the Chinese have always maintained the foremost rank, without a single exception. The cultivation of land is there carried to a perfection which throws us "barbarians" completely in the shade. The visitor to the Celestial realms cannot fail to be forcibly impressed by the appearance of the fields through which he passes. Everywhere there is the evidence of the highest agricultural skill and solicitude in the disposition of the farms, the ingenious processes adopted for protecting, fostering, and bringing to maturity the fruits of the soil; and, above all, in the means devised for insuring a constant and abundant supply of water for purposes of irrigation. In this respect we might well take a leaf out of John Chinaman's book. No matter what may be the distance of the fields from the source of supply, or the physical difficulties to surmount, they are invariably successfully overcome, and the fertilizing fluid pressed into the service of the farmer. All the various soils in China are classed under one or other of two great divisions. They are either rich and fertile or poor and barren. The former frequently possess so great a power of fecundation that a portion of the plants grown thereupon are developed to an extent which seriously interferes with the progress of the remainder. This contingency is provided for by mixing the soil with some of the poorer description, not so well endowed by nature with prolific elements. By the employment of proper manures the soil belonging to the second class is brought into a condition which enables it to grow large and excellent crops. In the application of these manures among the Chinese, practice and experience supply the want of scientific knowledge and refined chemical analysis. They have compensated for the absence of theory by a profound, patient, and long-continued observation, and have produced remarkably successful results by using discretion in the choice of their manures and varying them to suit the particular crops under cultivation. A brief enumeration of the principal manures will at once show the attention paid to the matter. There is, of course, the ordinary farm-yard manure, taken direct from the farm and distributed over the land. Sometimes this is mixed with human and animal excreta, allowed to ferment in a brick tank until it is "done," and then used immediately. A third fertilizer is prepared in small enclosures made of reeds, very appropriately termed by the natives "dunghouses." A collection is made in these receptacles of cinders, rice balls, dried leaves, excrementitious matter of all kinds, and other *debris* of an organic nature. In the preparation of this manure it is to be particularly noticed that the floor of the "house" is on an incline, so that all water may be drawn off. It is also covered with a roof or large lid to prevent the action of the wind and rain. A few days suffice to render this mixture an excellent manure. For the cultivation of China grass *(Urtica nivea)* a very similar fecundator is employed, only it contains in this instance a large proportion of waste water that has been used for culinary and domestic purposes, so that the whole mass is of a thick, semi-fluid consistency. There are also certain crops and plants which are grown by the aid of "burnt manure." A large heap of the various preparations already enumerated is set on fire, the ashes collected, and mixed and sown with the seeds of the plant. By the addition of beef bones to the stable or farm-yard refuse, and submitting the mixture to a long boiling, what is called "boiled manure" is obtained. The ground is watered with this liquid, and the Chinese regard it as one of the most efficacious fertilizers in their whole category. There is no doubt that the action of the boiling water conduces to a minute subdivison of the organic matter, and the gelatinous particles of the animal bones. The properties of lime are well known to the Chinese, who mix it with other ingredients. As a rule they seldom employ a single manure, but give the preference to a mixture of different kinds. They have two proverbs applicable to agriculture. The first is that "manure should be managed like gold," and the second, "it is cheaper to manure the land one has than to purchase more." The sewage of towns is utilized by collecting it in earthen pits placed near the fields or main roads, drying it roughly, grindin;

it, and distributing it over the land. Sometimes the waste water from rice and dwellings is allowed to mix with the excreta, and after a short stay in reservoirs, employed in irrigating the fields, either by means of open drains or usually by buckets. The manner of irrigating the rice fields is similar to that known among us as the catchwater system. While advocating the principle of utilization of sewage which is universal in China, it must not be supposed the same means would answer with us. Buckets are the ordinary implements of distribution, and the pits in which the fecal matter of every village is collested are of the rudest construction and very imperfectly closed. The odor is of a most repulsive nature, although the Celestials scarcely seem to notice it. We may certainly imitate that principle, but we must Anglicise the *modus operandi*.

Space will not allow us to more than allude to the most prominent of all the Chinese preparations, that of tea. In the interest of our fair readers it must be stated, although we regret to dispel agreeable illusions, that they are very much mistaken if they imagine they ever drink the "real thing." Neither the Chinese nor the Japanese drink the same kind of tea as we do, nor in the same manner. On the contrary, a particular description is prepared for exportation, and very little of any other kind ever comes to France, England, or America. It may not be generally known that an excellent oil, fetching a very high price, is obtained from the berries of the tea plant, which has the reputation of never turning rancid. A considerable number of women are employed in the tea trade, their daily earnings averaging about 8d. per diem. The hand labor is very onerous, but lately MM. Glover have introduced some mechanical improvements, which are under trial. It has been asserted that there is no nation, people, or even tribe under the sun which is unable to prepare some description or other of an intoxicating liquor. Our Celestial friends are no exceptions to this assertion, and manufacture a national eau-de-vie from rice, sorgho, and other grain. At Han-Keow there is a distillery on a large scale, which the author was permitted to inspect. He mentions that the products are impregnated with an oily taste exceedingly disagreeable to any but native palates. The best paid and best cared for workmen in China are considered to be those who are employed in the silk manufacture. They are lodged, fed, and paid at the rate of 8½d. a day, the whole expense to the master being estimated per head at 1s. 7d. per diem of 12 hours' labor, from 6 A. M. to 6 P. M., allowing an hour for meals. The masons at Han-Keow receive from 4½d. to 5½d. and two meals a day according to their ability. At Pekin out-door labor only lasts during 8 months of the year, in consequence of the severity of the winter, the thermometer falling frequently to 15 deg. below zero. In the other months the diurnal working hours number 8½, but there is not the same regime and discipline among the Chinese workmen as among ourselves. The former "knocks off" work just when he likes, indulges in tea and tobacco, and then recommences a condition of affairs not exactly suited to the temperament of Western employers. As an example of this Oriental intermittent arrangement we may notice the hours observed in a large establishment at Pekin, commencing at 6 A. M. An hour is allowed for breakfast at 7.30 A. M.; at 10 A. M. ¾ of an hour is devoted to the little indulgences already mentioned; the second meal abstracts an hour at midday; and at 3.30 P. M. another ¾ of an hour is appropriated to a similar object as the first. Curious as this style of working may seem to us, it may be very justly remarked that some allowance must be made for the influence of the climate and the physical organization of the men. While on the one hand a Chinaman can exert for a short period a degree of muscular force which no one would anticipate from his comparatively frail appearance, he is incapable of prolonged exercise. Frequent interruptions in his toil appear to be indispensable to him, at any rate in his native country. A perusal of the history of China proves indisputably that the inhabitants are people who for ages have shut their doors against the advent of strangers. Time may possibly break through these barriers, but, judging of the future by the past, the development of the resources of that vast kingdom must be accomplished by other agencies and other heads and hands than those which have allowed them to remain *in statu quo*, it may be truly said, from generation to generation.

# WATER—GOOD, BAD, AND GOOD ENOUGH.

From "The Building News."

The Royal Commission, of whom Sir W. Denison is chairman, and Dr. Frankland and Mr. John Chalmers Morton his colleagues, say that absolutely pure water is not to be found in nature. Even at the moment of its condensation in the atmosphere from invisible vapor to visible cloud, water absorbs gases, and when it falls to the earth as rain it percolates through strata or flows over surfaces in some degree soluble, and dissolves quantities of solid matter varying from 3 lbs. to 50 lbs. in every 100,000 lbs. of water. The Commissioners give the following as the chief characteristics of unpolluted water: "It is tasteless and inodorous, possesses a neutral or faintly alkaline re-action, rarely contains in 100,000 lbs. more than $\frac{1}{2}$ lb. of carbon and $\frac{1}{10}$ lb. of nitrogen in the form of organic matter, and is incapable of putrefaction even when kept for some time in close vessels at a summer temperature."

This water may be spoiled in its passage to the sea in many ways, which may be brought under two general heads, "Sewage" and "Manufacturing Refuse." Sewage is a very complex fluid. A large part of its most offensive matter is human excrement, and also urine thrown down gully holes; but, mixed with this, there is the water from kitchens containing vegetable and animal refuse, and that from wash-houses containing soap and the animal matters from soiled linen. There is also the drainage from stables and cow-houses, and that from slaughter-houses. In fact, say the Commissioners, sewage cannot be looked upon solely as human excrement diluted with water, but as water polluted with a great variety of matters—some held in suspension and some in solution—but both present in such a condition as to render it impossible, in the present state of our knowledge, practically to cleanse and purify sewage so thoroughly as to make it safe for drinking even when largely diluted with unpolluted water.

A great deal of the manufacturing refuse is passed into the sewers as the readiest way of getting rid of it, and then it merely adds other ingredients to those already passing down them; but where the manufactories are situated on or near a stream, and the water made use of in the process of manufacture is afterwards transferred directly to the river, polluted by admixture with the special matters used in the different processes, such refuse matters can be treated separately as manufacturing pollution. These may be classified thus: Pollution by dye, print, and bleach works; by chemical works; by tanneries; by paper making; by woollen works; and by silk works.

Of the different kinds of pollution affecting rivers, animal organic matter as it occurs in sewage is that which renders water not only most offensive to the senses, but most likely to injure health both by its gaseous emanations and its, deleterious effects when used as a beverage. Rivers so polluted frequently contain from 1 lb. to more than 2 lbs. of organic carbon, and from $\frac{1}{3}$ lb. to $\frac{2}{3}$ lb. of organic nitrogen, in 100,000 lbs. Pollution by vegetable organic matter, such as that caused by dye and print works, stands next as regards offensiveness, water so polluted being excessively unpleasant not only to the sight, but in warm weather to the smell. It often contains twice as large a proportion of organic carbons as sewage water does, but owing to the smaller proportion of nitrogen in vegetable substances it rarely contains more than $\frac{1}{5}$ lb. of organic nitrogen in 100,000 lbs. of water.

Chemical works contribute chiefly mineral impurities, which often communicate to water extreme hardness and other disagreeable and even poisonous properties.

Having reviewed the remarks of the Commission on good water and bad, let us see what they say in respect of rendering polluted water good enough to be allowed to flow into any river or stream from which it is not intended to take water immediately for domestic use. The prohibitory standard is as follows:—

(1). Any liquid containing, in suspension, more than three parts by weight of dry mineral matter in 100,000 parts by weight of the liquid.

(2). Any liquid containing, in solution, more than two parts of weight of organic carbon, or $\frac{2}{10}$ part by weight of organic

nitrogen, in 100,000 parts by weight of the liquid.

(3). Any liquid which shall exhibit by daylight a distinct color when a stratum of it, one inch deep, is placed in a white porcelain or earthenware vessel.

There are other stipulations which apply more particularly to certain manufacturing towns, but as applicable to towns in general the above are the most important ones.

This standard can be attained, say the Commissioners, by the present known methods of filtration, either through soil in the way of irrigation or through filter beds. The Commissioners regard the irrigation of land with town sewage in a different light to that in which it has been usually regarded. They say that the purification of sewage by irrigation takes place when it passes *through* the soil to a considerable depth, and not merely, as has been often said, by running over its surface. The Commissioners find that the filtration of sewage through either porous soil or sharp sand has the same effect in purifying it that irrigation has; that is to say, it purifies it to a degree which makes it admissible into rivers or other streams such as we have mentioned. The only difference between the two processes, viz., simple filtration and irrigation, is that the former is not remunerative, while the latter is so. Of course, the advisability of adopting one or the other method will depend in any town on the facility for acquiring land for the purpose of irrigation. Where that can be done at a reasonable outlay it is the better method, but where land cannot be had the other method claims attention.

It is curious that, so many attempts to filter sewage having failed, this simple method of dealing with it should be the one at last recommended by the Royal Commission; but when we consider the manner in which such attempts have been made, it is clear that it is not filtration that has been wrong, but the mode of filtering. There are three ways of passing water through a filter-bed—(1) horizontally, (2) upwards, and (3) downwards. Both the former methods have been tried and have failed, for good reasons given by the Commissioners; the latter method, however, is the one they find to effect a purification of the sewage. When water or sewage is passed upwards or sideways through sand or other filtering material, the interstices become full of liquid but devoid of air; whereas, by downward filtration, after shutting off the sewage from one bed and turning it on to another, and so on alternately, which would be the method adopted in practice, the air follows the last of the sewage down into the sand, and thoroughly permeates it; and when sewage is again turned on to that bed it encounters air in its descent and becomes oxidized or purified to the degree recommended by the Commissioners as admissible into rivers. It is not difficult to see why this latter method should be so much better than either of the others. By this method the matter held in suspension in the sewage is arrested on the surface, where it can be easily got at for removal, while by the horizontal method the solid matter lodges amongst the filtering materials and fouls it, and by the upward method the same matter lodges underneath the filter-bed, and is difficult to be got at for removal, besides the inconvenience resulting from the lighter particles of it being carried up into the filtering materials and fouling them.

The inquiries into the pollution of rivers in Lancashire were expected by the Commission to result in some practical conclusions upon the influence of such rivers on the health of the people, and questions were addressed to all the municipal bodies and Boards of Health within the Mersey and Ribble districts, whether the river, stream, or canal passing through or by their town was a source of ill-health or discomfort; and having before them the opinions of the authorities on this subject, and having also the actual statistics of mortality within their respective jurisdictions, and information on the density of population, on the number of cellar dwellings inhabited within the place, the provision of water-closets and privies, the sufficiency of the water supply, and other points bearing generally on the health of the people, and having made themselves acquainted with the condition of the running waters throughout the district, the Commission are not able to say whether the liability to ill-health in any town is influenced by its proximity to a filthy river. This is partly owing to the incompleteness of the health statistics laid before them; but, besides this, it was with astonishment the Commissioners found

that Boards of Health in several large towns, and many smaller ones, were not able to inform them of the death-rate within their districts, still less to give them information of the health within particular divisions of those districts.

## ON THE MANUFACTURE OF IRON AND STEEL BY DIRECT METHODS.

(*Continued from page* 241.)

The cost of producing a ton of iron blooms directly from the ore, by the bloomary process, varies greatly with the price of the dressed ore, which will depend on the proximity of the mine to the forge, and the richness of the crude ore. Thus, the cost of the two tons of dressed ore employed to make the fine iron of the Ausable forges, was estimated by Mr. Rogers, in 1868, at not less than $18.00, while the one and a-half tons of ore consumed at New Russia would not probably cost more than one-half that sum. The following estimate made by a highly competent iron-master, in 1868, may serve as a guide to the cost of producing iron at that time in New York :—

| | |
|---|---|
| 2 tons of ore | $10 00 |
| 300 bushels of charcoal at 8c. | 24 00 |
| Wages | 9 00 |
| General expenses | 3 50 |
| Cost of the ton of blooms | $46 50 |

The above prices are in American currency, which, at that time, was equal to about $\frac{89}{100}$, making the gold-value $37.20. The estimate of another manufacturer, in Clinton county, gave $7.00 for wages. It will be observed, moreover, that the amount of charcoal, in the above estimate, exceeds the average consumption for the production of a ton of blooms, which may be taken at about 270 bushels.

To produce a ton of blooms from cast-iron, in what is known in Sweden as the Lancashire hearth, there are consumed, according to an authority cited by Percy, 23 cwt. of pig-iron, and $\frac{9}{10}$ tons of charcoal. In New Jersey and Pennsylvania the conversion of the pig-iron is, for some purposes, effected by a somewhat similar process, which involves two operations, the melting in the running-out fire, and a subsequent treatment in the sinking-fire, as it is called, which is a bloomary forge very like that used for the ore in the direct method. To produce a ton of blooms in this way, there are consumed 24 cwt. of pig-iron, and 100 bushels of charcoal, according to one authority, while another estimate gives 120 bushels; the quantity varying both with the quality of the crude metal, and the charcoal; while, with some arrangements, the consumption of fuel is much greater. The mean of these, 110 bushels, at 18 lbs. to the bushel, would give almost exactly $\frac{9}{10}$ of a ton, the amount used in Sweden. The quantity of charcoal consumed for the production of a ton of pig-iron in the United States varies greatly, but in the best constructed and more modern furnaces, like those of Michigan, with rich ores, will not exceed 130 bushels of charcoal of the above weight, which gives for 24 cwt. of pig-iron 156 bushels. Thus, added to 110, equals 266 bushels, the total amount of fuel required to produce a ton of blooms by means of the blast-furnace with the charcoal-finery. There would appear to be but little difference, so far as the consumption of the fuel is concerned, between the cost of producing bloom-iron by the direct and indirect methods just described. The first cost of the establishment for the former is, however, less, and this is probably one of the reasons which has led to the adoption of the direct method by the bloomary forge in Northern New York.

The conversion of the oxide of iron to the metallic state, under the influence of solid carbonaceous matter, or reducing gases, takes place at a temperature considerably below that at which the affinity of silica for the oxide of iron is exerted. Even the compound of titanic acid with oxide of iron is decomposed at a red heat in contact with hydrogen gas, the iron being wholly reduced to the metallic state. If it were possible to effect this reduction, and subsequently to eliminate the silica and titanic acid from the metallic iron, ores containing these impurities might be made available for the direct method of conversion; but the practical difficulties

of effecting such a separation are such that the only available modes of treating such ores as contain considerable amounts of these impurities, are to smelt them in the blast-furnace with proper fluxes, or to effect as complete a separation of the impurities as possible, before submitting them to the process of reduction. This, in the case where heavy granular ores are mixed with quartz and feldspar, as for example, at the Palmer ore-bed, already noticed, is attained by washing away the lighter materials. Where, however, the impurity is chiefly titaniferous iron, as in the Moisie sands, the separation may be readily effected by means of magnets, a process which is equally advantageous where magnetic iron ore is mixed with lighter impurities, as quartz or silicious minerals.

The use of magnets for this purpose has long been taken advantage of, and various machines with permanent and with electro-magnets have been contrived. A simple and ingenious arrangement for this end, which has been invented and patented by Dr. F. A. H. Larue, of Laval University, Quebec, appears to be novel in the mode of its working, and is very efficient and cheap. The mixed sand or crushed ore is poured through a screen, into a hopper, the discharge of which is so arranged as to open and close at proper intervals of time, and falling from this, is spread in a thin and uniform layer, upon a series of aprons arranged, with interspaces, between two parallel endless bands, which pass over two horizontal cylinders. These aprons, charged with ore, are made, by the movement imparted to one of the cylinders, to pass from beneath the hopper, and under a series of permanent horse-shoe magnets, 800 in number, each capable of sustaining about 5 lbs. weight, arranged upon transverse bars, in 5 rows of 160 magnets each. Beneath these is a tympan, covered with muslin, which, when the iron ore is passing beneath them, is in the contact with the poles of the magnets. So soon, however, as the magnetic portions of the ore have arranged themselves, by magnetic attraction, in adhesion to the under side of the tympan, and the apron has moved from beneath, and gone forward to discharge the non-magnetic portion of the ore at the foot of the machine, the tympan is momentarily withdrawn a short distance from the poles, and the adhering magnetic ore falls in the open space between two aprons, into a receptacle placed below. This process of loading and unloading the magnets can be repeated twice in each minute.

These machines, as now constructed, occupy a space of about 6 ft. by 5, and are 4 ft. high; they are said to cost, at Quebec, about $500 each. One of these dimensions will, according to Dr. Larue, treat in an hour 3 tons of sand holding one-third of magnetic ore, separating from it 1 ton, containing over 99 per cent. of magnetic grains. I have myself seen only a smaller machine, the first one constructed, which had a capacity of about ½ that just stated. The motive power required is very small, and the mechanism, as will be seen from the description, exceedingly simple. Dr. Larue observes, that, inasmuch as a rich sand may be passed through the machine as rapidly as a poor one, the yield is directly proportionate to the amount of magnetite present, so that a sand containing one-fourth as much as that above mentioned would yield about 6 tons of purified sand in 24 hours. Even very poor sands may, probably, with this machine, be treated with advantage. The same process of purification may doubtless be applied with advantage, after crushing, to the preparation of lean massive magnetic ores for the bloomary fire, or for other direct methods for conversion into iron and steel. A process of partial reduction, at a low red heat, will render non-magnetic iron ores attractable by the magnet, a reaction of which Chenot long since proposed to take advantage, for the purification of such iron ores as are not naturally magnetic.

In accordance with the well-known fact that the reduction of oxide of iron takes place at a temperature very much below that required for its subsequent carburation and fusion, it has been shown that the charge of ore in a blast-furnace is converted to the metallic state some time before it descends to the zone in which melting takes place. It forms, when reduced, a spongy mass, readily oxidized, which, by proper management, can be compressed and made to yield malleable iron, or, by appropriate modes of treatment, may be converted into steel. This fact has been the starting-point of a great number of plans designed to obtain mal-

leable iron and steel, without the production of cast-iron and the employment of the processes of puddling and cementation. This, it is true, is attained in Catalan and bloomary forges, but the attention of many inventors has been, and still is, directed to the discovery of simpler, or at least of more economical methods of obtaining similar results. A short sketch of the various new processes will not be without value, as bearing upon the utilization of the iron ores of Canada, and especially of its iron sands.

Of these, the method of Chenot is best known. His experiments seem to have been commenced about 40 years ago, since we are informed that he had erected a large furnace for the direct treatment of the ores of iron, in 1831, although his results were not brought before the public until 20 years later, at the International Exhibitions of 1851 and 1855. I was a member of the International Jury at the latter, and had an opportunity of studying Chenot's process as then conducted, on an industrial scale, at Clichy, near Paris. A description by me of the process as then and there practised, will be found in the report of the Geological Survey for 1855–57. Rich peroxide ores were broken in small pieces, mixed with a portion of charcoal, and placed in large vertical rectangular muffles or retorts, enclosed in a gas-furnace, and heated to redness. The ore, after being reduced to the state of metallic sponge, passed downwards into an air-tight cooling-chamber, which was a continuation of the muffle, and when sufficiently cooled, was withdrawn. The spongy metal, thus obtained, was then exposed to a welding heat in a proper furnace, and formed into balls, which were afterwards treated like the balls from a puddling-furnace, and gave malleable iron. By impregnating the metallic sponge with oily and tarry matters, and afterwards expelling these by heat, a sufficient amount of carbon was fixed in the metallic sponge to convert it into steel. By grinding, compressing, and melting this carbonized sponge, cast-steel of a superior quality was manufactured at prices which, it was claimed, were much below the cost of steel prepared by cementation of bar-iron. This process was subsequently introduced in several places in France, Belgium and Spain, where it was applied to the manufacture of bar-iron, and up to 1863, at least, was worked on a considerable scale at Baracaldo, in Spain, where, in 1859, about 10 tons of iron were manufactured daily from iron sponge.

A very important modification of the process already described, in which the heating was effected externally and indirectly, consisted in the internal or direct method of heating. In this the outer furnace and the admixture of charcoal with the ore were both dispensed with. The vertical reduction-chamber was filled with ore only, which was reduced by the action of currents of heated carbonic oxide gas, obtained by forcing air, at a pressure equal to half an inch of mercury, through 2 generators filled with ignited charcoal. This mode of producing the sponge was found much more economical than that by indirect or external heating. The working results of the direct method, as carried on at Lamarade, in Spain, in 1863, are given by Percy; from which it appears that for the production of 1 ton of blooms, there were consumed 1.87 tons of charcoal. The greater part of the fine Swedish iron used at Sheffield for the manufacture of steel, is produced from charcoal made pig, treated in a charcoal-finery, known as the Lancashire hearth, and is obtained with a consumption of charcoal, which, for the united processes of reduction and refining, amounts to 1.90 tons for the ton of blooms, a result almost identical with that of the process of Chenot. (Percy, "Metallurgy," pp. 342–596.) The modified Catalan forge, and the American bloomary fire, as we have seen, produce malleable iron with a consumption of charcoal which is not very much greater, and with a simpler, and probably less expensive apparatus than that required for the Chenot process; while the method by the blast-furnace permits of the use of ores which are unfit for treatment by any of these direct processes.

The patents granted to Clay, in England, in 1837 and 1840, were for the manufacture of malleable iron by a process essentially the same with Chenot's earlier method of indirect or external heating. According to Clay, hematite ores were mixed with one-fifth of their weight of charcoal, coke, or other carbonaceous matter, and heated to bright redness in a clay retort, or other suitable vessel, until the ore was converted to the metallic state. When the reduction was complete, the

spongy iron (without previous cooling, as in Chenot's plan) was transferred directly to a puddling-furnace, where it was brought at once to a welding heat, made into balls, and then wrought into blooms in the usual manner. This process was tried on a pretty large scale near Liverpool, in 1845–46, and although iron was regularly made by it for some time, and to the amount of 1,000 tons, the process was not found to be commercially profitable, and was abandoned.

The process of Renton, patented in the United States in 1851, was very similar in principle and mode of working to that of Clay. The mixture of ore and coal was introduced into a vertical muffle or retort, which was inclosed in the flue or chimney of a furnace, not unlike an ordinary puddling-furnace. The contents of the muffle, being sufficiently heated, were reduced to the metallic state, and, from time to time, discharged from the bottom, into the furnace, where the spongy iron was exposed to a welding heat, and wrought into blooms. This process, after having been essayed on an industrial scale at Cincinnati, and at Newark in New Jersey, was abandoned. A similar fate attended the trials, on a large scale, of Harvey's patented process, at Mott Haven, near New York, about the same time. In this, the coarsely powdered ore, mixed with charcoal, was placed on inclined trays or shelves of steatite, in a heated chamber connected with a welding or balling-furnace. The flame from a fire below was made to pass through the chamber, and the ore, being at length reduced to the metallic state, was transferred to the hearth below, and there converted into blooms. For a farther description of these various processes, and the similar plan of Yates, the reader is referred to Percy's "Metallurgy," pp. 330–348.

Chenot's plan of reducing the ore by a current of carbonic-oxide gas was adopted by Gurlt, who used the direct mode of heating, already noticed. The gases from the generators charged with fuel, were led through flues, into the vertical reducing-chamber, a blast of air being at the same time introduced into the flues, in sufficient quantities to keep up the combustion of the gases. By this means, according to the specification, "there passes into the shaft a mixture of flame and carbonizing and reducing gases, by which the iron ore is heated" and carbonized. According to Gurlt's patent specification (No. 1679, London, July 16, 1856), by continuing, for a sufficiently long time, the action of the gases, the resulting iron sponge may be more or less carbonized, so as to yield, by subsequent fusion, either cast-iron or steel. These partially carbonized products he proposed to melt in a reverberatory gas-furnace, the blast of air into which is to be "so regulated that it exactly burns the gas produced in the generators," and that neither unburned gases nor unconsumed air escape; the object being to obtain a neutral flame, which should not alter the sponge upon the hearth. In this way carbonized sponges from rich ores, are said to have been successfully converted into cast-iron in Spain.

Gurlt's ingenious specification thus involves the idea of first reducing the iron ore to a metallic sponge, and afterwards carbonizing this sponge, so that, by subsequent fusion, it may be converted into cast-iron or steel. Although the conception of thus carbonizing the iron while in a spongy state, is probably novel, the use of carbonaceous gases or vapors for carbonizing iron, and converting it into steel, is not new, as may be seen from the patent for this purpose granted to Macintosh in 1825. The experiments of Percy upon iron wire have also shown the rapid carbonizing effect of coal-gas and heavy oily vapors, like those of paraffine ("Metallurgy," pages 109 and 773); and, according to Marguerite, carbonic-oxide gas, at an elevated temperature, yields up a portion of its carbon to iron, which is thus converted into steel. Practical difficulties have hitherto prevented the application of hydro-carbon gases and vapors to the carbonizing of bar-iron on a large scale.

With the results of Chenot, Gurlt, and Macintosh before us, we are prepared to understand the process of Dr. George Hand Smith, of Rochester, New York, which is just now attracting some attention in the United States, for the production of steel. The crushed and purified ore, or iron sand, mixed with a portion of pulverized charcoal, is heated in a kind of reverberatory furnace, with an arrangement which permits the vapor of petroleum of coal-tar to pass through the mass, thus aiding in the reduction, and finally carbonizing the resulting sponge, which

is then transferred to a puddling-furnace, to be wrought into iron, or, if properly carbonized, into steel.

Before proceeding farther, mention should be made of some other methods which have been devised for the treatment of iron sands, and for their conversion into iron or steel. In 1851 a patent was granted to Stenson, for a process for working the iron sands of New Zealand, and similar ores from India. These were to be mixed with small portions of clay and lime, with or without the addition of charcoal; the mixture was ground in a pug-mill, with water, and formed into lumps, for subsequent treatment in the blast-furnace. In 1862, Moreau proposed to mix iron sands with iron filings or turnings, and then incorporate them with fuel, such as peat-coal or coke; the mixture being made into blocks, which were to be smelted in suitable furnaces. In 1866, Mr. James Hodges, who was not acquainted with the experiments of Moreau, moulded the iron sands of Moisie into blocks with peat, and by treating these, after drying, in a proper furnace, succeeded in converting the ore into malleable iron, at a single operation.

Messrs. Whelpley and Storer, of Boston, effect the reduction of the iron sand ore, or pulverized ores, on the hearth of a reverberatory furnace, which is heated, in part, by pulverized coal, borne by a blast of air over the fire of solid coal upon the grate. In this way the furnace-chamber is filled with a volume of burning coal-dust, which can, by regulating the supply of coal and of air, be made either oxidizing or reducing. The heated ore upon the furnace-hearth is thus reduced to the metallic state, balled and made into blooms, with, it is claimed, a great economy of fuel.

It has also lately been proposed to convert these sands into steel or cast-iron, by melting with a sufficient admixture of charcoal in crucibles, or other closed vessels, heated from without. This is, in fact, nothing more than an extension of the dry method for assay of iron ores. A patent for making steel in this way, by treating rich ores, mixed with carbonaceous matter, in air-tight melting-pots, was granted to Lucas, in 1791, and a similar claim was made by David Mushet, in 1800; while, according to Percy, "experiments in the direct production of cast-steel from iron ores, in crucibles, were made by Riley, at Dowlais, a few years since, and although excellent steel was occasionally produced, it was not found possible to insure uniform results."

More recently, Ponsard has brought forward a similar process, the results of which were communicated to the French Academy of Sciences, July 19, 1869. This arrangement consisted of a number of fire-proof crucibles about 8 in. in diameter and 40 in. high, which were placed in a reverberatory gas furnace, the mouths of the crucibles being fitted into openings in the furnace-roof, for convenience of charging. The lower part of the crucible is perforated, and rests on the sole of the furnace, which is furnished with gutters leading to a depression or basin in the middle of the furnace-hearth. The crucibles are charged with the ores, mixed with proper fluxes and about 12 per cent. of carbon, sufficient to effect the reduction and carburation of the iron, which, under the influence of a very intense heat, melts, and, running through the holes in the bottom of the crucible, collects in the basin in the middle of the furnace. According to Ponsard, a ton of coal is consumed for each ton of iron produced, so that the process cannot be recommended for its economy of fuel. He, however claims as a great merit of this process, the complete separation of the fuel from the carbon required for the reduction of the ore, so that for the furnace, inferior kinds of combustibles, which, if brought directly in contact with the ore, would injure the quality of the metal, may be used with safety and advantage.

The process patented by Johnson, January 22, 1868, as described in the "Practical Mechanic's Journal" for June, 1869, is, however, exactly similar, in all its details, to that of Ponsard, which was first announced as a novelty to the French Academy, July 19, 1869, 18 months later. In a specification dated at Quebec, July 16, 1869, Dr. Larue claimed, and subsequently received Letters Patent for Canada, for a process similar in design to that of Johnson, of which he was ignorant. Although there were differences in detail, the avowed object in both plans was to separate the ore, with the carbon required for its reduction, from the fuel (which might, consequently, be of an inferior quality), and to permit a continuous charging

and discharging of the crucible. The difficulty of constructing sufficiently refractory crucibles for the intense temperature, and the small yield to be expected from such a process, would perhaps prevent it from ever being used for the manufacture of cast-iron. Dr. Larue, however, anticipated its application to the production, not of cast-iron, but of cast-steel, which would require a very nice adjustment of the proportions of carbon to secure a uniform quality in the product; as in the ancient processes of Lucas and Mushet, and the more recent experiments of Riley, mentioned by Percy, and referred to above.

Two processes for the production of steel are those which depend, respectivly, on the combination of cast-iron in proper proportions with malleable iron or iron sponge, and with oxides of iron. In the specification of a patent granted in 1839, Heath claimed the production of steel by melting with cast-iron, either wrought-iron, or oxides of iron or manganese. In a second patent, granted to him in 1845, he described an arrangement by which the cast-iron was kept in a molten condition, in a gas-furnace, while pure iron in scraps, or in sponge, obtained by reducing oxide of iron, as in Chenot's and Clay's method, was added from time to time; until, by trial, the proper quality of metal had been obtained, after which the liquid steel was run into ingots. Other processes, based on the reactions embodied in Heath's first patent, are those of Uchatius (patented in 1855), who melts granulated cast-iron in crucibles, with a certain proportion of oxide of iron, and thus obtains a fine quality of steel (a process already specified in Wood's patent, in 1761); and that of Brown (patented in 1856), who, to produce steel, melts, in crucibles, mixtures of pig-iron and clipped bar-iron. This method is practised to some extent in Sweden, where it is known as the Obersteiner process.

In the process of Obuchow, which appears to be successfully used in Russia, fine pig-iron is melted, and run into a large crucible, previously heated to whiteness, and holding magnetic iron ore, alone, or with titanic iron sand and iron and steel scraps. The crucible is then heated till the contents are perfectly fluid, some nitre and arsenious acid are added, and the steel run into ingots. By a somewhat similar process to this, Ellershausen attempted to produce steel, by pouring molten cast-iron upon previously oxidized sheet-iron, heated to redness, and placed in a heated vessel. The oxide dissolved in the molten iron with violent chemical action, decarbonizing it, and producing a kind of steel; but it would probably be difficult to effect a thorough conversion of the iron without keeping up the heat from without; which was not done in Mr. Ellershausen's first experiments, made in Montreal, in the spring of 1868.

The above processes, however, involve the use of crucibles, and it had become a great desideratum to produce cast-steel upon the open hearth. This was the aim of Heath, in his process described above; but the difficulties in producing and controlling a heat sufficient for the purpose, were so great as to render the efforts in this direction but partially successful, until the regenerative gas-furnace of Siemens placed in the hands of metallurgists the means of fusing large bodies of steel on the hearth of a reverberatory. Provided with this, the Messrs. Martin, of Sireuil in France, have succeeded in producing cast-steel, in charges of three and four tons at a time, by melting down wrought iron in a bath of cast-iron, by what is known as the Siemens-Martin process. The products thus obtained attracted much attention at the Paris Exhibition, in 1867, and the process has since been widely adopted in Europe and in the United States; where it was first introduced by Messrs. Cooper, Hewitt & Co., and is now in successful operation at their works at Trenton, New Jersey.

Beginning with a bath of 6 cwt. of pig-iron on the hearth, malleable iron, as puddle-bars, for instance, is added, previously heated to whiteness, and rapidly dissolves in the molten cast-iron, until, at the end of about four hours, the charge amounts to three tons, and will be found to consist of a soft, nearly decarbonized metal. It is then recarbonized by the addition of from 5 to 8 per cent. of spiegeleisen (manganesian cast-iron), as in the Bessemer process, and run in moulds. The bath of molten metal, during the process, is protected by a covering of fused slag or cinder.

The furnace-bottom for this process is made up of a silicious sand, which must not be quite pure, but contain some alu-

mina or other bases, so that, under the influence of the high temperature, it may harden, without melting, forming an impervious crust, which will resist for a considerable time the action of the molten steel. The upper part of the furnace is built of Dinas fire-brick. Attempts have been made to use an admixture of oxide of iron with the pig-metal in this process; but it is found that the corrosive action of the oxide, at a high temperature, upon the furnace-bed is such as to preclude its employment. The entire cost of a furace with a capacity of producing three ons of cast-steel, with gas-producers, generators, and all the apparatus for moving the ingot-moulds, is, in England, about £500 sterling.

This process, it is true, cannot compete with the Bessemer or pneumatic method for the cheap production of cast-steel in large quantities; but while the latter is applicable only to certain fine kinds of cast-iron, comparatively free from phosphorus and sulphur, the process in the open hearth permits the employment of other qualities of iron. These, in being reduced, by puddling or otherwise, to the condition of malleable iron, are deprived of the impurities prejudicial to steel, before being added to the iron bath. While, therefore, the Bessemer process will probably remain without a rival for the treatment of the purer cast-irons, the production of steel by the open hearth will perhaps become even more important, because of wider application. The Heaton process, for which so much was claimed as a method for the production of steel from impure cast-iron, by the action of nitrate of soda, appears, from the late careful studies of Gruner, destined to become sudsidiary to the production of steel in the open furnace. Gruner concludes that it "can never, from any point of view, become a substitute for the Bessemer and Martin processes. These produce ingots of steel, or homogeneous iron, from pure brands. The Heaton process deals with impure brands, and seeks to convert them into a refined metal, more or less purified, the treatment of which has to be finished in a Siemens furnace." He further declares that the only advantageous way of treating the products of the action of nitrate of soda on cast-iron, is to submit them to the Siemens-Martin process.

Mr. Bessemer has very recently made experiments upon the working of his process under pressure, by which he obtains such an elevation of temperature as, it is expected, will enable him to introduce malleable iron into his converters, and thus effect in them what Martin does upon the open hearth. In the mean time Siemens has, by the aid of his furnace, been able to carry out a part of the original plan of Heath, who, in 1845, proposed to reduce iron ores, by heating them, in small fragments, with charcoal, in a close vessel, as in the methods of Chenot and Clay, and to add the resulting spongy iron to the bath of molten cast-iron. The reduction is, by Siemens, effected by a plan which combines the indirect and direct methods of Chenot.

Above the furnace, and immediately over the bath of molten cast-iron, which occupies the hearth, are two large tubes of refractory clay, enclosed in an outer casing, through which the flame from the furnace passes, and allows these tubes, or reduction-chambers, to be heated, with their contents, to redness. They are charged from the top with finely broken rich ore, through which a current of previously washed and purified carbonic oxide gas, from the common gas-generator of the furnace, is forced, and reduces the ignited ore to the condition of a metallic sponge of pure iron; this, descending, is at once dissolved in the molten cast-iron bath, and effects its conversion to steel precisely as in Martin's plan, where solid malleable iron is made use of. In certain cases, as with very finely divided ores, the reduction is effected by an admixture of about 10 per cent. of charcoal, or other carbonaceous matter.

Siemens has already manufactured excellent cast-steel by this method, and there is no doubt that, in the case where pure oxides, free from sulphur and phosphorus, can be obtained, the mode of directly producing steel with spongy iron may be advantageously employed.

A simple and ingenious process, based, like that of Siemens, on the original suggestion of Heath, has recently been devised and patented by Mr. Robert G. Leckie of Montreal. Having found that when finely-divided iron ore, as magnetic iron-sand, was made into lumps with peat, coal, or other carbonaceous matter, not in excess, and exposed to redness, out of a

current of air, there results a nearly pure spongy metallic iron, he proposes to obtain iron in this way, and add it to the bath of molten cast-iron, in a reverberatory gas-furnace. The ore, agglomerated with the reducing material, is to be placed in one or more large chambers or ovens, in the rear of the hearth, and, when sufficiently heated to effect its reduction, is to be added to the bath of molten iron. He expects soon to test, on a working scale, this mode of making cast-steel in the open hearth, to which the purified magnetic iron sands of Canada, from their freedom from sulphur and phosphorus, would seem to be peculiarly well adapted.

It is one of the great advantages of the Siemens furnace, that by a judicious regulation of the supply of air, and by proportioning it to the gaseous fuel, it is possible to obtain, at will, either an oxidizing, a reducing, or a neutral flame ; a point of much importance in the fusion of metals in the open hearth, which was already indicated in Gurlt's specification.

The employment of gaseous combustibles has been greatly extended since the successful use of the regenerative principle by Siemens. This consists in allowing the heated gases, after combustion in the furnace-chamber, to pass out, downwards, through two chambers packed with fire-bricks, so arranged as to allow a free passage of air between them, to which they impart their heat ; the waste gases passing off into the stack at a temperature seldom above 300 deg. Fahr. After an interval of from half-an-hour to an hour, the current is changed, and the gases are led off through another pair of regenerators ; while those which had been heated by the escaping gases are now used to conduct the air and gas for keeping up the combustion ; these passing in through the heated regenerators, have their temperature greatly raised before entering the combustion-chamber. By alternately making each pair of regenerators the channels for the passage of the gases to be burned, and for the waste products of combustion, a very intense temperature is maintained in the chamber, with very little loss of heat.

Coal and dry wood have generally been used in the gas-generators, where, by partial combustion, the solid fuel is converted into combustible gases. With wet fuel, a large amount of steam becomes mingled with the gases, where its presence is very objectionable. This difficulty has, however, been entirely obviated by a system lately devised in Sweden, which may become of great advantage to Canada. I have therefore thought it best to copy from Mr. Abram Hewitt's Report on the Production of Iron and Steel at the Paris Exhibition of 1867, the following account of this valuable invention. This report, published by the United States Government, contains excellent drawings of the furnace :

"The furnace devised by F. Lundin, of Carlstadt and Munkfors, is designed for the consumption of turf and peat, without drying, and of wet saw-dust or other moist fuel : an invention deemed so valuable that the Association of Swedish ironmasters have rewarded Lundin by a gift of $10,000, which, in Sweden, is a very considerable sum. In this furnace, the fuel is fed by a hopper, into a reservoir resting upon an inclined grate, supplied from below with air from a blower. The products of the combustion thus maintained, pass through a condenser, where all the moisture in the gas is condensed. The gas then passes to the heating-furnace, which is furnished with Siemens's regenerators."

It is found easy to use fuel holding as much as 45 per cent. of water. The gas, as it issues from the producer charged with such wet fuel, contains one-fourth its weight of watery vapor. It passes at once into a chamber in which, from perforated pipes, small streams of cold water are discharged, crossing each other in various directions, and filling the chamber. By this, the gas is greatly cooled, and the acid and tarry matters present, with much of the steam, are condensed. It then passes through a second chamber, filled with wrought-iron bars, arranged like the bricks in the heat-regenerators, and kept cold by a stream of water trickling over them. The gas, which at the time of its escape from the producer, was heated to the melting point of lead, is thus cooled down until it retains only 4 per cent. of watery vapor.

"The expense of building a full-sized furnace, in Sweden, is about $2,500 in currency, and it is estimated that such a furnace will utilize 1,700 tons of fuel in a year, at a saving proportioned to the cost of other fuel in the particular locality

where it is employed. In Sweden, it is estimated that the annual saving, resulting not merely from the fuel, but from the repairs of the furnace, and the increased temperature, amounts to over $5,000 per annum, on the product of each furnace. * * * * The gas produced by seasoned wood contains more water than that which proceeds from the Lundin condenser. The duration of the furnace is simply surprising, and is to be attributed, probably, to the fact that there is no cinder. In 8 weeks, the thickness of the roof, 4 in., was only diminished from $\frac{1}{4}$ to $\frac{1}{8}$ in., and the side-walls were entirely uninjured. So wonderful is the success of this system of condensation, in connection with the Siemens regenerators, that, in Sweden, and, in fact, everywhere where moist fuel is employed, the Lundin furnace will supersede every other. Its great merit is, that it is available for any kind of fuel whatever. In the United States it is believed that this arrangement might be employed advantageously for washing the gas obtained from mineral coal; but its chief merit consists in the fact that in mineral regions, far removed from the coal fields, it is possible to establish iron works, using saw-dust or peat with entire success and great economy. In the lumber regions of Lake Superior it will be found to have a special value, because there is an abundant supply of pig-iron, accessible to the saw-mills on Green Bay and in Michigan, producing enormous quantities of saw-dust, slabs, and waste-timber."

By the aid of the Lundin furnace, combined with the regenerators of Siemens, Rinman has succeeded in producing steel by the Martin process, using only pine saw-dust for fuel. When such results can be obtained with saw-dust, or with ordinary peat, the want of mineral coal need no longer be an obstacle to the development of the metallurgical industry of this country.

The gas-furnace of Boëtius, which is now used for zinc-smelting, and in many glass-works, in France, is simpler and less expensive than that of Siemens. It does not make use of the regenerative principle, and hence the waste heat can be employed for boilers or for other purposes. In this furnace, however, there being no condenser as in the Lundin system, only dry fuel can be made use of. The air which serves to burn the combustible gases in the furnace-chamber, is heated by passing between the walls of the generator and an outer casing, these walls being made very thin, and supported at intervals by bricks, which are built both into them and their envelope. This furnace does not enable us to obtain a heat sufficient for the production of cast-steel, but is well adapted for puddling and reheating iron, as well as for zinc and glass-works, and is said to economize from 30 to 33 per cent. of the fuel. This description is taken from a paper by Gruner, Professor of Metallurgy at the Ecole des Mines of France, which appears, with working-drawings, in the "Annales des Mines," for 1869, fifth part.

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The iron interest is the principal support of Youngstown, Ohio. The rolling mill of Brown & Bonnell employs 600 men, with a pay-sheet of $40,000 a month; manufactures 500 tons of iron a week into all sizes and shapes, from the smallest nail to the heaviest bar, and consumes 325 tons of coal a week. Shedd, Cartwright & Co.'s rolling mills employ 100 men and boys, pay $7,000 wages monthly, manufacture 6,000 tons annually of hoop and band iron. Two machine shops find active work. The first, that of Homer, Hamilton & Co., uses 1,200 tons of iron annually. Ward & Majorum use 1,000 tons a year of iron, give employment to 80 mechanics, turn out first-class machinery, engines, rollers, and all of that class required by furnaces and rolling mills. Arms, Bell & Co., nut and washer factory, employ 20 men. Park, Stedman & Co. manufacture all classes of bolts, employ 50 men.

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The fall of a large mass of rock between Heidelberg and Weisloch has brought to light the works of a silver mine which was known to the ancient Romans. There is no silver ore of any importance left, but a very rich zinc ore is met with in large quantities.

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Engineers are engaged in making a final survey of the Portage and Ripon Railway.

# HEAT IN THE BLAST FURNACE.

From "Engineering."

The manner in which the heat developed by the combustion of the fuel in a blast furnace is disposed of, has from time to time been made the subject of various estimates by different metallurgists, and although these estimates differ materially in their details, and although, moreover, no one of them, probably, can lay claim to any very great precision, yet they nevertheless possess considerable interest, indicating, as they do, the direction in which improvements are to be made if increased economy is to be obtained. The more carefully any estimate is made, the greater is its value for the purpose we have named, and we consider that the hearty thanks of our practical iron manufacturers are due to men who, like Scheerer, Tunner, Ebelmen, Bunsen, Playfair, and more recently, I. Lowthian Bell and C. Schinz, have devoted their time and energies to the investigation of the action of the blast furnace, and have endeavored with greater or less success to determine from the practical results obtained, the laws by which these results are governed. It is only those who have conducted such investigations who can thoroughly realize the labor and perseverance required to establish a single fact connected with blast-furnace working. An investigation of the action of a blast furnace is dependent upon a number of other collateral investigations; such, for instance, as the determination of the amounts of heat rendered latent during the liquification of the iron and slags; of the specific heats at different temperatures of the materials forming the charges; of the heat absorbed during the decomposition of the peroxide of iron, and of the limestone; of the losses of heat by radiation, etc., and other kindred matters. More than this, there is considerable difficulty in obtaining correct data as to the performance of any given furnace; the charges and blast contain variable quantities of moisture, and variations also take place in the quantities, temperature, and composition of the gases evolved, which render it necessary that a large number of observations should be made at brief intervals if a reliable average result is to be obtained.

Taking all these matters into consideration, it is not to be wondered at that differences should exist between the estimates which have been made as to the manner in which the heat developed is disposed of in the blast furnace; but we have the satisfaction of knowing that, as reliable data accumulate, these estimates will become more and more reliable, and of greater practical value. We have no intention of entering here into an investigation of the various estimates which have been made by our leading experimenters; but we wish to point out a source of loss of heat in the blast furnace, of which, so far as we are aware, none of the estimates hitherto published take any account. It is usually considered that the heat developed is disposed of in effecting the reduction of the peroxide of iron, the decomposition of the limestone, the fusion of the iron and slags, the decomposition of the moisture in the charges and blast, the heating of the tuyere water, and in supplying the losses caused by radiation, convection, and conduction from the sides of the furnace, and by the heat carried off in the waste gases. That almost the entire quantity of the available heat can be accounted for by these means is an undoubted fact; but there is, nevertheless, at least one other source of loss of heat which appears to us to be worthy of attention. This loss consists in the heat rendered latent during the expansion of the blast from the pressure at which it is supplied to the furnaces to that at which the waste gases issue from the throat. The assumed insignificance of this loss has, we believe, caused it to be generally disregarded by metallurgists; but although we acknowledge that its amount is small, it is, we think, not so small as to render it unworthy of notice, and some very simple calculations will, we consider, show that this is the case.

It was long ago proved by the researches of Laplace and Poisson that if a given weight of any gas was allowed to expand freely whilst it was being heated, a greater quantity of heat was required to raise its temperature any given number of degrees, than if during the heating process the gas was maintained at a constant volume. In other words, the specific heat of a gas

maintained at a constant volume is less than that of the same gas maintained at a constant pressure, the difference between the two specific heats being due to the amount of heat rendered latent during the expansion of the gas. It follows from this, that if a gas heated under any given pressure is allowed to expand to a lower pressure, its temperature will fall, and *vice versa*, the variation in the temperature in the case of air being given by the following formula :

$$T = \left\{ (t + 461.2^\circ) \times \left(\frac{P}{p}\right)^{0.29} \right\} - 461.2^\circ$$

In this formula $t$ = the temperature of the air in degrees Fahrenheit at the pressure $p$, whilst T is the corresponding temperature at the pressure P. The pressures P and $p$ are measured above a vacuum and may be taken either in atmospheres, pounds on the square inch, or any other convenient unit of measurement—care, however, being taken that the same unit is used in each case. The 0.29th power of the fraction $\frac{P}{p}$ can of course be readily obtained by the use of a table of logarithms.

The manner in which this formula can be employed to determine the loss of heat due to the expansion of the blast in a blast furnace can, perhaps, be best illustrated by an example. Let us suppose, then, the case of a furnace consuming, say, 26 cwt. of coke per ton of pig produced and blown with blast at a pressure of about $3\frac{3}{4}$ lbs. per square inch, or, say $1\frac{1}{4}$ atmospheres, this blast being heated to 1,000 deg. Fahr. Under these circumstances, the quantity of blast supplied to the furnace would be about $6\frac{1}{2}$ tons per ton of iron smelted, and it is the loss of heat due to the expansion of this quantity of blast which we have to determine. At the mouth of the furnace the pressure would, in all probability, be practically equal to that of the atmosphere, so that in passing through the furnace the pressure of the gases forming the blast would be diminished from $1\frac{1}{4}$ to 1 atmosphere. Introducing these quantities into the formula above given, we find the reduced temperature of blast due to the amount of expansion just mentioned to be :

$$\left\{ (1000 + 461.2) \times \left(\frac{1}{1.25}\right)^{0.29} \right\} - 461.2$$
$$= (1461.2 \times 0.9374) - 461.2 = 909.5^\circ ;$$

or, in other words, the mere expansion of the blast would alone cause a diminution of its sensible heat by 1,000—909.5=90.5 deg. The specific heat of air, when maintained at an uniform pressure, being 0.238, the heat rendered latent in the manner just mentioned amounts, in the case we are considering, to $6.5 \times 2240 \times 90.5 \times 0.238 = 313{,}608$ pound-degrees or thermal units ; and, as each pound of carbon consumed in a blast furnace may be taken as producing, on an average, about 6,000 thermal units, the quantity of heat rendered latent by expansion represents the consumption of $\frac{313{,}608}{6000} = 52.26$ lb. of carbon, or say, about half a hundredweight of coke. This quantity, although it forms but a small proportion of the total consumption, is yet, we think, worth taking into account when an estimate is being made of the disposal of heat in the furnace.

It remains to be considered how far the source of loss we have pointed out is likely to be affected by the modifications which are being made in blast furnace working. The tendency of the day is towards larger furnaces supplied with blast at higher temperatures and pressures, and this increase of temperature and pressure will, of course, increase the loss, from the cause we have mentioned. But, on the other hand, the new furnaces require less fuel, and consequently a less weight of blast than those worked with blast at a lower temperature and pressure, and it is probable that this reduction in the weight of blast required per ton of iron will more than counterbalance the increase in the amount of heat rendered latent due to the other new conditions. In conclusion, there is one deduction to be made from the facts we have stated, to which we desire to direct attention, and this is, that the nitrogen contained in the blast acts as an absorber of heat, which is never recovered. Roughly speaking, about 5 tons of the $6\frac{1}{2}$ tons of blast—which we supposed in our example to be supplied to the furnace per ton of iron smelted—would be nitrogen, and the calculation we have given shows that this nitrogen, whilst expanding during its passage through the furnace, would render latent an amount of heat equal to that produced by the consumption of the furnace of about $\frac{5}{6.5} \times 56 = 43$

lbs. of coke. This loss cannot be recovered, whatever may be the way in which the waste gases are utilized, and it is, moreover, a loss which, as it cannot be discovered by the ordinary modes of observation, has been hitherto generally neglected.

## THE RIFLING OF HEAVY GUNS.

From "The Engineer."

The strongest argument that the advocates of the Whitworth gun are able to adduce is that the normal, or Woolwich gun, is comparatively inaccurate, liable to damage from the breaking up of shot in the bore, and deficient in range. Few artillerists dispute the fact that these assertions are, to a certain extent true; the system of complete chilling has been abandoned, and only the heads of shot and shell are now cast in contact with cold iron. Projectiles fired from the guns of the Hercules and the Monarch turn heels over head in their flight; one gun in the Hercules has been temporarily disabled. The same fact is true of the gun carried by the little Staunch gunboat, and also of certain guns on board other vessels. The partisans of Sir Joseph Whitworth find in these things ample reason for condemning Mr. Frazer's guns, totally ignoring the fact that Mr. Frazer is in no sense responsible for the system of rifling adopted; while to this last, and to this alone, are due the failures of which they make so much capital. It is now tolerably certain that we are to have a 35-ton gun, although it is still doubtful whether this gun is to be made by Sir Joseph Whitworth or by Mr. Frazer; if by the former, it is not difficult to predict what the result will be; if by the latter, the result will altogether depend on the system of rifling adopted; for there is no reason to doubt that Mr. Frazer possesses both the means and the ability to produce a perfectly sound and trustworthy gun, as far as the question of endurance is concerned. But we want guns which will not only not burst, but will shoot straight; and projectiles which will neither give way in the gun, nor deteriorate by keeping. It is essentially necessary to a proper comprehension of this subject that our readers should bear in mind that the best gun in the world, as far as powers of endurance and cheapness are concerned, may prove a most unsatisfactory weapon if it be rifled on a bad system; and it is difficult to resist the conclusion that all the heavy guns we have now in our possession are defective in this respect. In fact, it is impossible to avoid the conviction that we cannot much, if any, longer continue to rifle guns as we rifle them now. The construction of a 35-ton gun affords an admirable opportunity for introducing something better. That that something is not the hexagonal, erroneously known as the Whitworth system, all but a few artillerists will admit. But opinions, even after the hexagonal system has been excluded, will no doubt differ as to what the rifling of the gun of the future should be. Ours may be plainly expressed in a few words.

In 1864–5 a competitive trial of 7-in. guns, rifled on various systems, was carried out by a select committee. The results obtained have already been published in our columns. They left no doubt in our mind that the best of the systems tried was, taking all things into consideration, Captain Scott's. Nevertheless, the French, or stud system was adopted, and to this stud system all the defects of our modern guns are attributable. We need not at this time describe the difference between the two systems, Scott and French, they must be well known to every one who will care to read this article. The record of events since 1864–5, proves that the conclusions at which we then arrived were correct. The stud system is, for heavy guns, a practical failure. We might occupy pages in explaining why. Among other reasons, it will suffice to say, that the method of construction necessarily adopted renders the shot weaker. The studs are blown off, the projectiles are honeycombed round the stud cavities, the studs themselves are so weak, that they cannot be used with a moderately sharp twist. The shot does not lie fair in the gun at the first, and being imperfectly supported in the chase, it comes out thumping up and down, and not unfrequently jamming and breaking up in the bore. All manner of changes in the

method of placing the studs have been tried, but at this moment it has not been settled how far apart the studs should be, nor how the shot should be balanced on them, nor is it known whether 2 or 3 rows of studs are better than 1 row. All that is known about the matter with certainty is that the French or studded system of rifling has failed to give good results with heavy guns, though it has answered, we believe, moderately well with small field pieces and such like comparatively tiny weapons.

The point to be settled, then, is, What shall the rifling of the gun of the future be? We hold that as no system tried in 1864–5 gave better results than Captain Scott's, that his system should now have a further trial on a larger scale, say with a 10-in. gun. If the results are as satisfactory as, reasoning from analogy, we have grounds to suppose they will be, then let a few more guns be rifled on the same system, and distributed throughout our fleets. In the course of a very few months, if not weeks, it would be known whether the Scott rifled gun possessed the advantages we believe it to possess, advantages which would suffice to justify its general adoption. The cost of the trial would be very small, as our readers will readily understand that it has nothing to do with a new gun, but only with a system of rifling which has already given satisfactory results. Here we have no novel metal, nothing abnormal in the system of forging, or unusual in the nature of the projectiles. Any large service gun, as yet unrifled, can have five Scott grooves cut in it without materially impairing its usefulness as a rifle on any other system, should the Scott system not justify our anticipations. The projectiles are of the simplest and cheapest character, ribs cast on them taking the place of studs let in. An experiment begun now, would, at a nominal cost to the nation, decide a most important point regarding the future of the 35-ton guns which are certain to be carried by our ships sooner or later.

## SILTING UP OF RIVERS.

From "The Mechanics' Magazine."

All engineers who have had anything to do with work in connection with rivers and streams are well aware that in the lapse of time very material alterations and modifications take place in their beds or channels. Frequently, the original course of the river is totally changed. Sometimes the bed is deepened by an increased scour, and at others it is rendered shallower by the deposition of foreign particles along its course. The latter is a more frequent occurrence than the former, and is due to both natural and artificial causes, which are deserving of investigation. The nature of the river channel has a very important influence in deciding the amount of silting up to which it may be subjected. Thus, if the river have a rocky bed, it very speedily becomes cleared of any loose earth or sand that may have originally adhered to it, and even supposing a heavy flood to bring down a quantity of mud and small particles in mechanical suspension, the hard rock would scarcely retain them any length of time after their deposition. A very moderate scour would suffice to remove them, and the bed would undergo scarcely any appreciable variation in level. Without the attribution of the fact to artificial causes, a river channel will sometimes become, from natural causes alone, silted up to such a degree that the stream in time of flood cannot find its way along its old course. Under these circumstances, after overflowing its banks and doing an incalculable amount of mischief to the riparian proprietors, it finally cuts out a new channel for itself. It does not always follow that the old bed is altogether abandoned, for in process of time the new course may become also choked up, and the stream will actually return to its original channel. So long as the silting up of rivers is accomplished by natural agency alone, a very trifling amount of dredging will suffice to keep the channel open, and if the bottom be of a sandy or gravelly nature, the state of it will more than pay the expense of procuring it. It may be mentioned that the silting up of rivers is nothing in comparison with that which takes place along the sea coast. The tendency for the bottom to silt up at Har-

wich is so great that the project of a harbor there had to be abandoned in consequence.

Directly we come to artificial causes, the silting up of the beds of rivers assumes proportions far in excess of those resulting from natural ones. Latterly, this has been traced to the enormous amount of liquid and solid pollution which is permitted to find its way unchecked, and, in many instances, unknown, save by its effect, into nearly all our rivers and streams. It may be stated that there is not a single natural watercourse in the country which is not polluted by artificial causes at some part of its course between its source and its mouth. However limpid and clear it may be at the commencement of its journey, it is nearly certain to become turbid, polluted, and contaminated before it arrives at the end of it. It was but a short time ago that it was indisputably proved that the bed of the Thames had been silted up several feet, owing to the enormous quantity of refuse and sewage matter it received from the drainage of the metropolis. Shoals and mudbanks had formed in situations where previously the bed had been smooth and even, and vessels could no longer pass places where they had previously ridden with a foot or two of water under their keels. The evil result of this accumulation of *debris* in the channel of a river is still more apparent when the dimensions of the stream are on a more limited scale than those of the Thames. If we select the Irwell as an example, the immense amount of refuse of every kind annually thrown into it has partially diverted its course in some places, and has raised the level of the bed to such an extent as in flood-time to seriously damage all the adjoining houses and other property. It is easy to comprehend how a diversion of the river is caused by the tilting up of part of the water-way. If a large quantity of *debris* be thrown into the stream from one bank alone, it immediately raises the level of that side of the bottom, and when a rush of water comes down it is driven to the opposite side, and thus endeavors to cut out a new channel in that direction by destroying and undermining the bank, an event certain to ensue after repeated attempts. From careful examinations of the level of the beds of the Irwell, the Irk, and other streams flowing through the large and populous manufacturing towns of Lancashire, the silting up has been found to be at the rate of nearly 2 in. per annum, or 1 ft. in six years. On the other hand, if care be taken to exclude all refuse and foreign substances from the river, the bed will gradually become free from the deposit that may have accumulated previously to the adoption of such precautions. Some years ago the town of Bacup was always inundated by every flood that occurred, but since a stringent prohibition has been put in force against the casting of rubbish into the river flowing through it, the channel has deepened and the houses are dry and safe even in extraordinary floods. The discharge of town sewage, manufacturing and other refuse of every description, may be said to be the cause of the silting up of all those rivers and streams which flow through inhabited localities. In no other country but our own is this wholesale pollution of rivers permitted. France, Belgium, and Prussia have long since legally provided for such contingencies, and punish with a heavy fine the infringement of the law. All manufacturers who produce a refuse of a description likely to impede, pollute, or render undrinkable the water of any stream, are compelled to construct reservoirs or tanks where the necessary subsidence may take place, and the supernatant liquid, if sufficiently pure, may be discharged into the nearest watercourse. The real truth of the matter with respect to the pollution of rivers by manufacturers' refuse is that the manufacturers find it pays a great deal better to make the river the receptacle for their refuse and by-products than to attempt to purify or utilize them. No doubt this is the fact, but still one portion of the community cannot be permitted to get rich at the expense of the lives and safeties of another.

The peculiar purifying action exercised by large masses of running water upon the deleterious and injurious substances they may contain, has long been a subject of remark, also of considerable discussion. It has been asserted by some that after the lapse of a certain time the water becomes completely purified and freed from all the noxious qualities imparted to it. This, it is needless to point out, is an error. That some of the contaminating and polluting qualities do become mitigated there is no doubt; but the longest river in Eng-

land would be incapable, during its whole course, of freeing its waters from sewage and other refuse, supposing it received them at its very source. As only the substances held in mechanical suspension form the deposit at the bottom of the river bed, the silting up of it favors the deposition, as it is easy to show. The particles held in suspension are carried along at a given velocity by the current, sinking lower and lower as they are borne down the stream. The greater the depth they have to fall before coming finally to rest, the longer are they held in suspension. It is thus that shoals accumulate so rapidly, for as they are raised above the bed, they intercept all the particles in transition before they have sunk low enough to reach the lower portions of the river bottom. A repetition of the same cause and effect continues until the shoal assumes such proportions as necessitates its removal or drive the stream to alter its course.

When there is a decided tendency to silt up manifested in the bed of any river, and sewage and manufacturing refuse are discharged persistently and in large quantities into it, there is very little use in attempting to combat it by means of dredging. The task is simply an endless one, and the expense exceedingly heavy, as it is very rare that the filth dredged up can be applied to any purposes whatever, not even for those of manure. While it retains most of its offensive properties, it has lost the greater portion of those which render it valuable as a fertilizer.

When a shoal reaches to such a size that its removal is absolutely necessary, there are one or two different methods of effecting this operation. Sometimes the material is not dredged up, that is, not actually taken out of the river, but disseminated, as it were, over a large area of the bed. Instead of excavating the shoal, and carrying the stuff bodily away, it is merely loosened or disintegrated, and the current then wafts the particles down stream, gradually depositing them in its course. The cubical contents of a shoal, which might be a serious evil when all in one mass, would be nothing when distributed over a mile or two of channel. One advantage of this distributing method is that the expense is comparatively very trifling, but it is of course inapplicable in instances where the current is very slow. A very ingenious machine has been lately used in the Mississippi for the purpose of removing shoals, and is known as Long's scraper, being the invention of Colonel Long, one of the United States engineers. It acts upon the principle just enunciated, and may be briefly described as a steamer provided with a frame containing a number of iron scrapers. Having approached the shoal the frame is let down, the iron scrapers fix themselves in the mass, the steamer gets under weigh and drags them right through it, stirring up and disintegrating the sand and mud in a most effectual manner. When the steamer has cleared the shoal and got into deep water the frame is hoisted up, she steams back again, and the operation is repeated as often as may be required. This invention is likely to be of great use in removing the silt that accumulates at the bar of harbors, where 18 in. or 2 ft. of sand often prevent ships from getting in and out until a very high tide bears them over.

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THE "Philadelphia Press" says that pure metallic lead is not believed to exist anywhere in a native condition. At all events its existence in that state has always been disputed. Yet a mine of such lead is again announced to have been discovered in Thuringia. Some years ago the same discovery was announced as having been made near Edinburgh, and quite an excitement was created amongst the incipient mineralogists of the good old town. It was afterwards discovered that the supposed native veins of metallic lead were artificial, having been produced by the penetration of musket bullets fired against the rock by a rifle company that had been out for a day's practice.

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THE Lafayette Iron Company's furnace is about 2 miles from the Terre Haute and Indianapolis Railway, on a branch of Otter Creek. The company was organized in April, 1868, and the furnace went into blast June 17, 1869. The capacity of the furnace is put at 20 tons per day.

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AN effort is being made to raise stock for the establishment of a farm implement manufactory in Zanesville, Ohio.

# WAR AND WATER.

From "The Scientific Review."

That inability to apply the principles of logic, or insufficient confidence in the soundness of those principles, not unfrequenty causes conclusions to be drawn which scarcely follow from the premises, has long been known; thus, we are told, that in the reign of Abdallah III. there was a great drought at Bagdad, and that, although the Mohammedan doctors issued a decree that the prayers of the faithful should be offered up for rain, the drought continued. The Jews were then permitted to add their prayers to those of the true believers, but the supplications of both were ineffectual. As famine stared them in the face, those dogs, the Christians, were at length enjoined also to pray. It so happened that torrents of rain immediately followed. The whole conclave, with the mufti at their head, were now as indignant at the cessation of the drought as they were before alarmed at its continuance. Some explanation was necessary to the people, and a holy convocation was held; the members of it came to the unanimous determination that the God of their prophet was highly gratified by the prayers of the faithful, that they were as incense and sweet-smelling savor unto him, and that he refused their requests, that he might prolong the pleasure of listening to their applications; but that the prayers of those Christian infidels were an abomination to the Deity, and that he granted their petitions the sooner to get rid of their loathsome importunities. Some conclusions about as logical have just been published by Mr. Ch. Le Maout, pharmacist, of St. Brieuc, in consequence of the drought we have recently experienced.

The connection of war and water is perhaps not studied by military officers generally, except so far as relates to the transport of large bodies of troops across seas and rivers; whilst the conclusion drawn by most non-military persons would be that the discussion of war and water must relate exclusively to naval warfare. If we accept the doctrine of Mr. Le Maout, we shall learn what lamentable results such ignorance may lead to. As Mr. Le Maout is the author of a work entitled "The Cannonades of Sebastopol, or the Cannon and the Barometer," published in 1856, it appears that he has occupied himself for some time with the question; and he considers that his observations, made during the Russian war, and published at the time, established in an unequivocal manner the condensing action of cannon upon cloud, and consequently their effect upon barometrical indications. This action was constantly observed in Brittany in from 100 to 120 minutes, although the distance from the seat of the war was more than 600 leagues as the crow flies. During the formidable cannonades of the siege of Sebastopol he notices that generally—in Brittany we presume—whenever the firing commenced the azure of the sky was overcast, and a fine rain or mist fell, frequently followed by heavy showers and then by wind. Afterwards, and as a consequence of these condensations, the barometrical column was put in motion, and rose at a speed and to a height proportioned to the extent of the cannonade. The record of the barometrical indications represented pretty exactly the extent of the firing when the effect was not modified by some great physical phenomena, such as a volcanic eruption or a great fire. Then the rarefying force neutralized the condensing force, and the barometer remained stationary until one or the other conflicting forces ceased to operate. But still more marvellous, and what attests the extreme sensibility of the instrument, he observed, that after six memorable engagements, followed by armistices of two or three hours concluded for the burial of the dead, the barometer stopped, and remained stationary during the whole time the burial was going on; then, just after two or three hours, at the moment when the cannonading recommenced, the column again gave signs of movement upward, and by its speed made up for lost time. It was this remarkable property that enabled him to calculate the exact time that was required for the force applied in the Crimea to exert its influence in Brittany.

And it is not cannon alone that possesses this condensing action. Mr. Le Maout has found that the explosion of mines and powder-mills, and even the sound of bells, produce a similar effect. Even the

simple striking of a village clock, and of those of churches and chapels, suffices, on the coast of Brittany, where they have almost constantly a humid atmosphere, to make the rain fall; but for this, certain physical conditions are necessary. The wind must be blowing from the south-west, and carrying rain-cloud, and the barometer must stand below 76 centimetres. In this state of things, when the temperature is not high, it is rarely that the striking of the hours does not show its condensing action upon the aqueous vapor, especially when the clouds are low, for the vibration of bells and of clocks striking only acts within a limited area. In the month of May, 1856, the year of the great inundations, he carefully observed the exact time of the fall of the rain, and found that, out of 133 times that it rained in the month, the fall occurred 76 times at the striking of the hours, 42 times at the half-hour, 8 times at the three-quarters, and 7 times at the quarter. He considers that it is the intensity of the sound, as well as the repetition, that has the most powerful effect upon the condensation of the vapor of water; and he explains that such observations cannot be made in Paris and other large towns, where so many noises are produced from fortuitous or accidental causes between the times of the striking of the clocks. Speaking generally, he maintains that all noises produced by physical or artificial causes result in the condensation of aqueous vapors. Thus the beating of the drum, and the sound of military music where brass instruments predominate, produce identical effects, and it is the same with heavily-laden wagons passing over paved streets, and with trains of loaded trucks on railways. The vapor of water being formed of myriads of vesicles of the smallest diameter, similar as to their fragility to soap-bubbles, it is not surprising that, by the powerful percussion of the aerial mass, they should break, and resolve themselves into rain. When we are enveloped in this vapor by a sky charged with rain-clouds, we are in a most impressionable medium, which, for its fragility, may be compared to a palace of glass. If, under these circumstances, we fire a cannon, all will be smashed to atoms, and necessarily fall about our ears. If, however, there be nothing above us but the azure of heaven, we may fire cannon and ring as long as we like, yet nothing will fall. "It is this," says Mr. Le Maout, "that the adversaries of my doctrine of condensation will not understand; they wish, as proof of the truth of it, that rain shall fall under all circumstances."

Now, were this the sole objection to Mr. Le Maout's hypothesis, he would certainly have grounds of complaint, for it must be acknowledged that there are many experiments which can only be successfully performed under favorable conditions, but in effect he admits that, whatever may be the conditions, the success or failure of the experiment is dependent upon the merest chance, for he adopts nearly the same argument as was used by Mr. George Shepherd, an English weather forecaster, to account for the fact that no dependence whatever could be placed upon his forecasts. "But," says Mr. Le Maout, "if it does not rain upon us when we fire the cannon, or when we ring, it may rain somewhere else, especially when the sky is charged with rain-cloud within the area affected by the sonorous body. Thus, not only may rain fall in the neighboring village, but even at immense distances, since in the great disturbances of the aerial mass by the formidable discharge of artillery at the siege of Sebastopol it often rained here (in Brittany), although not a drop fell in the Crimea." From this it would appear that our great pharmacist is not so much in want of correct premises as of ability to deal with them; but it is precisely this latter want that gives us the amusing absurdities he has treated us to. "Often," he continues, "the firing of the cannon and the sound of the bells clear the cloudy sky, and send the threatened storm afar."

Similar effects were observed, not only during the Crimean war, but during that of Italy, and of the Austrians and Prussians; and he observes that storms were more frequent than usual during those events. In confirmation of his views he reminds old military officers that at the siege of Antwerp the besieged were constantly under torrents of rain, and up to the knees in mud, but that as soon as the citadel was taken the rain ceased, and the weather became fine. They will remember, too, the memorable storm of hail, rain, and wind, which occurred before four or five o'clock in the evening on the battle-field of Solferino, which alone put an

end to the fury of the combatants, and saved the remnant of the Austrian army. In that case the physical force was accumulated by the powerful means used, which had the effect of concentrating the hurricane upon the battle-field itself, the battle acting incessantly like a suction pump. He accounts for the storm at Puebla and the non-success of French arms in Mexico in a similar manner, and it seems that even England may well be thankful that M. Le Maout's doctrine was not accepted half a century earlier. The success of England in some of her greatest conflicts with foreign nations has frequently been attributed to her knowledge of war and water; and (in another sense it is true) Mr. Le Maout attributes the loss of Waterloo by the French to the want of that knowledge. If, he observes, Napoleon I. had known this condensing power of cannon, which, by the way, he could better than any one else have observed upon so many fields of battle, he would not have undertaken, upon June 16th and 17th (the eve of Waterloo and day previous), the battle of Ligny, and the engagement with the rear-guard of Genappes, during which a storm occurred, commencing about three o'clock in the afternoon, and continuing for twelve consecutive hours to pour down torrents of water, which converted the ground into a perfect marsh, alike impracticable to man and beast. It was the twenty-four rounds fired on the retreating English columns that, in Mr. Le Maout's opinion, brought down the rain, and prevented the movement of the French troops until the following day, by which time the Prussians had arrived; hence the loss to the French of the battle of Waterloo.

It is difficult to determine whether Mr. Le Maout is the more worthy of admiration as a philosopher or as an historian; but as we are not called upon to give a decision, the question may consequently be left to our readers. We will content ourselves with explaining how the great discovery is to be turned to practical use, by recording a statement of the conditions which he regards as most favorable to success. The instructions are given for St. Brieuc, so that experimenters will have to make the necessary corrections for locality if applied elsewhere. Make the experiment with the wind blowing from the south-west and carrying heavy rain-clouds, and choose a day when the barometrical pressure averages less than 76 centimetres. Commence in the morning, before the misty bank formed on the surface of the English Channel is dispersed by the rays of the sun. The lower the temperature the better. Proceed by simultaneous explosions from one or several batteries every quarter of an hour. Upon this day all military target practice should be suspended; and if the experiment be made upon the day of a religious feast, when the bells are rung, the probability of success will be all the greater. If the experiment succeed, and it be judged that sufficient rain has fallen, transport the condensation cannons from Cherbourg to Brest, and fire again to stop the current of vapors coming from the ocean by condensing them in their passage. Thus, to have rain, fire at Cherbourg on the rainy winds of the south-west; to have dry weather, fire at Brest on the easterly winds which reach there after having traversed Central Europe, and been deprived of their vapor of water by the numerous bells in Christian churches and the noise of military exercises which they have met with on their way. There is, in Mr. Le Maout's opinion, reason to believe that if the condensation cannons, which act like a suction pump, were kept in energetic motion on the English Channel, the vapor of water would flow there and fall as rain, not only from the west, but from the Mediterranean and the Northern Ocean. Is this to be accepted as a result of superior technical education on the Continent?

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If protective tariff is class legislation for the benefit of manufactures, then it will stimulate manufactures, causing manufacturers to employ more men, pay higher wages, consume more agricultural products, and while creating a better demand for the farmers' crops, will lessen relatively the number of farmers who compete with each other in raising them. But as more employment and higher wages are just what all workingmen want, and fewer farmers and higher prices for crops are what all farmers want, the free traders are obliged to deny that protective tariff will in fact aid manufactures. If so, in whose favor is the class legislation?

# THE FRICTION OF STEAM ENGINES.

From "The Engineer."

If we did not believe that it is easy to say something new on a subject which has been in a very peculiar sense worn threadbare by the inventors of cylinder lubricators and steam greasers, this article would never have been written. So far as we are aware, all the information regarding the resistance of steam engines due to friction is to be found in the circulars of inventors, one or two papers read before engineering societies by the advocates of particular methods of lubricating engines, certain theoretical disquisitions contained in text-books of mechanical science, and perhaps a report or two in the "Journal of the Royal Agricultural Society." It is almost needless to say that the subject is one of very considerable importance; but it may be worth while to bring this importance home in a tangible form to the employer of steam power. It may be stated, in pursuance of this object, that it by no means follows that an engine giving a very high indicated duty per pound of coal is really the most economical that a manufacturer can use, for the simple reason that the power required merely to drive the engine may be so great as to render the saving in fuel valueless. A case in point suggests itself. An experiment was made some time since with a compound engine, the general particulars of which are before us. This engine was of the annular type; the large cylinder about 15 in., the stroke of both pistons about 35 in. diameter; the inner cylinder was the same, about 5 ft., the piston rods both laying hold of the same crosshead, which was connected with an overhead beam. The experiment consisted in shutting the steam off from the inner cylinder and driving with the outer annular piston alone. It was found that the engine, then indicating the same horse-power as before, failed to drive the machinery at the proper speed; and it was not till the indicated horse-power was augmented nearly 40 per cent. that the engine would do the work. On permitting the steam to find its way to the inner cylinder as before, the indicated horse-power fell to the original point, the machinery being driven at the proper speed. We shall not pretend to explain why this was the case. It is indeed difficult to understand why the fact that the inner cylinder, though open to the atmosphere, took no steam, should so enormously reduce the effective power of the engine. The facts are as we have broadly stated them, and there is no reason to think they would now want explanation if engineers had in times past devoted a little attention to the study of the phenomena of friction in the steam engine. We have no doubt whatever that many so-called economical engines are doing very bad work indeed; nor that many so-called wasteful engines as far as coal is concerned, are giving out a far higher duty than is generally believed. The entire subject is wrapped up in mist—a mist which can only be dispelled by careful experiments, extending over long periods, and properly and fairly analyzed. That a few engineers have conducted experiments on the friction of steam engines and other machines is certain; but it remains to accumulate in a single volume the statistics which these gentlemen possess, and to put them into a form which may render them generally useful. In pursuance of this object we have for some time past been accumulating data, as yet infinitely far from being complete. But these data have, at all events, done this much—they have satisfied us that ordinary theories regarding friction in steam engines based on investigations concerning the coefficients of friction between lubricated surfaces, apply most irregularly and imperfectly. In other words, there is no theory at present in existence which will enable us even approximately to predicate with certainty what the loss of effect by friction in any given engine may be. In certain cases, calculations made with this object will correspond, with surprising exactitude, with the results obtained through the indicator and dynamometer. But the engineer, resting satisfied with such occasional coincidences, is mistaken in his views. In scores of other instances enormous discrepancies will be found to exist between theory and practice—the almost total absence of frictional resistance in some engines contrasting strangely with the expenditure of power absolutely wasted, in others. It is

not the mere loss of fuel alone—although that is bad enough—that has to be considered in dealing with this subject. We find engines unable to do their work overloaded and worn out; boilers burned and overtaxed; grease and oil wasted; indeed, we go so far as to hold that every horse-power unnecessarily spent in overcoming the frictional resistance of a steam engine costs three times as much as if it were spent in doing useful work, and this without taking at all into account the fact that useful work returns money, while what we may term the internal work of the steam engine returns none.

The difficulties which lie in the way of ascertaining by actual experiment what the frictional resistance of an engine is, are very great; and to this cause no doubt is to be attributed the greater portion of the existing ignorance of the subject. The obstacles in the way are of two kinds. In the first place, it is very difficult to put a dynamometer, or brake, on large engines whereby to ascertain their duty; and, in the second place, the amount of friction varies not only in different engines, but in the same engines in a very extraordinary way. As regards the first difficulty, we can, in the case of pumping engines, ascertain precisely how many foot-pounds of work an engine actually gives out in the shape of useful effect, while the indicator shows the work done on the piston; but from these data it is impossible to calculate engine friction exactly, because our calculations are complicated by the greater or less efficiency of the pumps. It is possible that nothing can be more deceptive than the results obtained from pumping engines, and therefore we have no hesitation in rejecting their aid in dealing with questions of engine friction. Practically speaking, the only generally available test is the indicator used with the engine light and the engine loaded; but diagrams taken thus do not account for the extra friction due to the performance of work, though useful to some extent in their way; but no investigation of the qualities of an engine can be regarded as complete unless the dynamometer is used as well as the indicator.

As regards the variation in the loss by friction in the steam engine, a very great deal might be said which we shall not attempt to say now. It may induce others to experiment for themselves, however, if we place a few facts curiously illustrative of the peculiar phenomena of engine friction before our readers. In one case we conducted the experiment personally; for the results of the other we are indebted to a gentleman who, in superintending the replacement of ordinary boilers by the now well-known Howard boiler, has occasion to indicate a very large number of engines and on whose accuracy we can rely with certainty. In the first experiment which we shall cite we found the full power exerted by a rolling mill engine in the North of England—where, it is unnecessary to specify—to be 291.5-horse. This included the resistance due to a fly weighing 30 tons, a bar mill with 2 pairs of rolls working on heavy orders, and the requisite gearing. Engine and mill empty required, according to one set of diagrams, 74.8-horse power to run them at the working speed; but according to another set of diagrams, the frictional resistance of engine and mill is less than 35-horse power, and all the diagrams were taken within a few hours. We cite this case only to illustrate the difficulties engineers have to contend with in endeavoring to estimate the friction of engines under ordinary circumstances.

The other experiment is very interesting and curious as regards results. The engine was a double-cylinder traction engine, built by Messrs. Howard, of Bedford. The cylinders are 8 in. diameter and 12¾ in. stroke. The engine shaft can be disconnected from all the rest of the machinery, so that the whole work done by the steam consists in turning the crank shaft and overcoming the friction of the bearings, pistons, etc. With 60 lbs. of steam in the boiler, the engine making 190 revolutions, indicated unloaded 2.64-horse power. The engine was then set to drive a brake loaded to 16-horse power, the link being put in full gear; under these conditions the engine indicated 22.55-horse power. The frictional resistance was therefore increased by the fact that the engine was now doing work, to 6.55-horse power, or to nearly three times that of the unloaded engine. This is all plain sailing, but now comes a most remarkable fact. The throttle valve was thrown full open, or nearly so, and the engines linked up—that is, worked expansively at the same velocity, 190 revolutions per min. The load on the brake, etc., remaining

absolutely unaltered, any engineer would predict that, under these circumstances, the result would be the same; far from this being the case, however, it was now fond that the effective work or duty of the engine being unaltered, the indicated power *was only* 19.86-*horse power*, so that the friction of the engine when linked up was only 3.86-horse power, or a little more than one-half that of the engine working in full gear. Lest there should be any mistake about this, the brake was then loaded with 504 lbs. With the link in full gear the engine indicated 44.88-horse power; the link was then put in the first notch, and the throttle valve fully opened, everything else remaining unchanged, when the power fell to 40.92-horse, the frictional or internal resistance of the engine in the latter case thus being 3.86-horse power less than in the immediately preceding experiment. How are these facts to be accounted for? Is it that the varying strain on moving surfaces in contact, due to the action of expanding steam, is attended with less frictional resistance than is present when the metals are under the steadier strain of non-expanding steam? We shall not pretend to answer these questions. These are the facts for the consideration of those interested.

Is it too much to hope that engineers who have the opportunity, will take up this subject, and endeavor to throw light into what is at present a very dark and unexplored region of mechanical engineering? We are convinced that the results would, when time and perseverance had multiplied data, be found of very great value to those who desire to see the steam engine undergo the real improvement of which it is still capable. We venture to suggest that the general practice of indicating the engines tested by the Royal Agricultural Society while running against the brake, and the publication of those diagrams, would be productive of much good. Suppose the society begin at Oxford?

## STEAM ROAD ROLLING.

From "Engineering."

A report upon the economy of road maintenance by steam rolling, written by Mr. F. A. Paget, printed by order of the Metropolitan Board of Works, and now going through its second edition, is likely to do good service in bringing about a most important and extensive reform. And if we do not compliment Mr. Paget so much as *Punch* has done, by calling him a Colossus of Roads, we at all events congratulate him for having taken much pains in gathering information and placing it in a useful practical shape upon the matter of economy in road construction and maintenance. Information of this sort is especially hard to obtain, for as the metropolitan streets belong to a great number of parishes, and as all these parishes are looked after by a number of vestrymen, who have their own independent notions of doing business or pretending to do it, it will be readily understood, that parochial statistics are hard to glean and too often not worth much after they are obtained. Mr. Paget, indeed, hints at this difficulty in introducing the compendious table at the end of his report, a table presenting the mileage area, and cost of maintenance of the various macadamized roads within the metropolis. But although somewhat imperfect, this table, as well as the statistics which are plentifully scattered through the report, form an ample basis upon which to prove the advantages of steam over that of horse rolling, or of vehicular road adjustment. To the mechanical mind, the question scarcely admits of argument at all, and the pity is that, for the most part, those under whose control the metropolitan roads are placed would require the aid of a surgical operation before the value of Mr. Paget's arguments could be got into their heads. The vestries, however, we believe and hope, hold the Board of Works in much esteem, and though that latter body has set but a poor example in employing horse rollers only upon the Victoria embankment, we trust this report, printed "by order," may have due weight.

In the proper construction of a macadamized road, three distinct interests have to be consulted—that of the rate payers, that of the public, and that of the cattle employed upon such roads.

There is (we quote the figures from the report) an average sum of £781,000 spent yearly by the thirty-nine local metropolitan governments, upon the various roads and streets, of which about £280,000, is devoted to the maintenance of 1,126 miles of macadamized thoroughfares. There are horses and vehicles of an approximate value of £4,000,000, using these roads, and yet scarcely a step has been made in the right direction towards making a good road first of all, and then preserving it in the most suitable condition for the traffic. The time has come for a change in these matters, however; and if vestries are too slow or too obtuse to discharge those duties with which they are intrusted, other and more comprehensive powers will at last be compelled to act for the general good, and sweep aside the various petty powers that now exist chiefly to perplex.

Setting out of the question granite paving, the great cost of which renders its universal application impossible, but which, nothwithstanding the inconvenience arising from the noise it creates, and the insecure foothold it affords, is the noblest, most enduring pavement in the world, the problem of construction and maintenance with which we have to d› refers exclusively to macadamized roads.

Every one is unfortunately familiar with the aspect of roads newly covered, or repaired, with the layer of small broken granite, every fragment of which lying loosely with regard to its fellows presents sharp edges to the feet, human and bestial, that come in contact with it; every one is familiar with the piteous spectacle of laboring horses toiling with painful steps over the cutting surface, with the draught of the load behind them increased threefold, and the difficulties of progress infinitely multiplied; every one is familiar with the sight of horses fallen upon the cruel stones, and with all the inconvenience, the difficulty and pain, inseparable from the use of such a roadway. By slow degrees this rugged surface becomes more easy; it takes months sometimes, however, with the pressure of horses' feet, with the action of wagon wheels, until a portion of the road is made comparatively fit for travel, to the neglect of the rest, and this portion, unduly used, may often be seen worn hollow, or cut into ruts, while the stones lie untouched upon another part. And here it is as well to note that—so says Mr. Paget—parochial deference exhibits itself in a custom of renewing macadam towards the fall of the year in London, so that poor men's beasts may smooth the way for rich men's cattle when the season comes.

But, on the other hand, it is not so common to see a road properly laid down and fit for traffic before traffic is turned upon it. Let us take the latest instance that has become beneath our notice—that of a portion of the Wandsworth road. There were the same preliminaries for relaying, the old road taken up, the new formation laid down, the same layer of broken granite, and then the steam roller—one of Messrs. Aveling & Porter's 15-ton rollers. Over the rugged surface it worked to and fro, compressing the fragments beneath the weight of its broad cylinder, not crushing them so much as turning them over upon their broadest surface, until, with each succeeding pressure, the intermediate spaces became smaller, the stones were more closely packed together, and the interstices being filled with grouting, the rollers went to and fro, bringing the surface into shape, consolidating, giving it a firmness and a surface which traffic could never do. And this in a few days. Or take the evidence of Mr. J. Newlands, borough engineer to Liverpool, who has been working Aveling's road roller for two years and a-half or more. He finds "that besides its advantages in making a newly-coated macadam road perfectly smooth in a single night, it is of no less utility in forming the foundations of new roads. Formerly the traffic had to be turned on these foundations to consolidate them and render them fit to receive the protective coatings of paving or macadam respectively, a work which took from 3 to 6 months, according to the locality. Now, when the foundation is laid, it can be rendered fit for paving and macadam in a day or two." We could multiply instances in support of these views, if it were necessary, for it would be indeed strange if, amongst those who have power over our roads, there were not a few who formed an exception to the general rule of ignorance or indifference. And with these indisputable proofs in favor of steam rolling, which remove the advantages derived entirely out of the field of theory, into one of certain practice, what we have already said with reference

to Mr. Paget's report is obvious: that the arguments to convince of the utility of this system are of themselves almost superfluous; it is the constant reiteration of them which is necessary.

It would, however, be hardly fair to Mr. Burt, of the eminent Millbank firm, did we omit to mention, in passing, his objections to road rolling. That gentleman does not consider "that there is any economy or saving of material in the use of a horse roller on our hard London roads," while the steam roller crushes the material over which it passes, and if rollers be employed they should assimilate closely in their action to that of the passing vehicles, which have for the most part to achieve the road rolling of the metropolis. It is hard to conceive that such an opinion, coming, as it does, from an experienced witness, can be an unprejudiced one. It is the action of the wheels of vehicles in the slow process of working down the surface that pulverizes the broken granite until, according to Mr. Burt's own statement, nearly a third of the granite is ground up into dust, to the perpetual annoyance of the public. The amount of material thus wasted is enormous; the amount of power required to pulverize so much hard stone is enormous, and of course means so much extra wear and tear of horses, and yet it is argued that such is the best way of consolidating and surfacing a road. On the other hand, the action of the road roller is as we have described it, and when once the road is placed in order by it there is no further possibility of any pulverization except on the top exposed surface, there being no loose stones; the attrition of each against the others on all sides is done away with.

But while it is almost impossible to exaggerate, and absolutely impossible to deny the advantages gained by the public traffic on steam-rolled roads over those that are left untouched, it may be urged by local governments that the extra cost of this process and the first cost of the engine are too great to justify its adoption. On this point we may again quote some of Mr. Paget's statistics, somewhat imperfect, it is true, but still sufficient. Thus Mr. Heaton, the Birmingham engineer, estimates a saving of £5,700 in the case of steam rollers, the present cost of maintenance being £13,000. Mr. Newlands, of Liverpool, whilst hesitating to give exact figures, is certain of the great saving obtained. Mr. Holmes, borough engineer of Sheffield, estimates the economy at 40 per cent. The surveyor of Maidstone finds that 20 per cent. of saving is the result of using a steam roller. In like manner those parish surveyors in London who have adopted this system are unanimous in their opinion. Mr. Howell, of the St. James's district, finds a saving of $\frac{2}{3}$ of the material. The parish engineer of St. George's places the economy of material at $\frac{1}{4}$, and so on. And it should not be forgotten that, widely as the results assumed to be obtained differ from one another, the discrepancy is fully accounted for by the varying nature and extent of the traffic in different localities. But whatever may be the actual amount of material saved, it is certain that in unrolled roads, the large percentage that is lost can be only in the form of dust, ground by painful efforts from the granite fragments, and scattered broadcast by every wind. The great economy which experience points out can be effected by the use of the roller, is obviously more than sufficient to counterbalance the cost of the extra labor put upon the roads, and although it follows as a matter of course that a somewhat larger amount of metalling must be laid down at first, on account of the close packing the stones undergo in the process of compression, this increase must not be laid against the steam roller's account. On the contrary, the durability of the road, its freedom from repairs, and the smoothness of its surface, increase far more in proportion than the extra amount of metalling required.

It being proved, therefore, that rolled roads possess great advantages over those unrolled, that they are smoother, more lasting, more free from dust, requiring less repairs, the comparison between the relative merits of steam and horse rollers may be questioned, and considering that the Board of Works, while they show an anxiety to promote the use of the former, yet still continue to employ the latter, it may be imagined that some motive of convenience or economy must guide their choice in this matter. Independently of cost, the use of horse rollers is attended with many inconveniences. The pressure laid upon the road is, for the most part,

insufficient, involving a longer process of reducing the surface, and, as a consequence, a prolonged interference with the public traffic. The number of horses required for the operation produces a like inconvenience, and the manipulation of the machine has the same effect. With the steam roller it is different; it occupies less room, it works more rapidly, and does its work more effectually. It is handled more readily, and leaves the road upon which it operates sooner free for traffic. One old objection still rules against the system, it is true, namely, that it may frighten horses, with possibly serious results. But the fact is that it does not frighten horses, and such animals as would "shy" at a steam roller would find ample excuses on every highway for similar evolutions. This difficulty, which has been made so much of, is indeed one of the great retarding causes of the more free introduction of steam on common roads. Experience teaches differently. But few horses become restive even in passing beneath a railway bridge, when a train thunders overhead, making the earth vibrate, and every fibre of the iron structure ring. So in America horses do not become frightened, though they run alongside locomotives and trains as they pass through the street.

The last question, that of comparative cost between the use of horse and steam rollers, may be briefly summed up. In Bordeaux, the comparative outlay per ton per mile is as 14d. to 7d., just one-half in favor of steam rollers. In Paris, the figures per sq. metre are 0.151 francs, against 0.108 francs. In London the cost is half as much; in Calcutta it is about the same; while in America, the experience of Mr. Green, the Chief Commissioner of the Central Park, who recently purchased one of Aveling & Porter's rollers, is as follows: "That with one day's rolling with it, at a cost of $10, as much work could be accomplished as in two days with a 7-ton roller, drawn by 8 horses, at a cost of $20 per day. Hence, the work done by the steam roller was twice as much, and the cost only one-quarter that of the 8-horse roller." In this case the element of time is taken into consideration, giving a result of fourfold in favor of steam rolling. In the other statements, the cost alone is estimated, which, if taken in conjunction with the time saved, would produce practically the same results.

We have given so much space to the consideration of this subject, because we are impressed with its importance. We have freely used Mr. Paget's statistics and data, because they have been carefully collected and well put together, and we trust that his efforts towards reform in the matter of street construction and maintenance may result in the success which alone will give to the metropolis such roads as we should possess.

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THE Mahoning, O., "Courier," says: "This week has seen the shortest-lived miners' strike on record in this valley. The delegates' meeting, representing most if not all of the banks, which met at Hubbard on Monday, decided to strike against a reduction of 10 cents per ton. The proprietors yielded to the point, and, after being out of the mine only one day, the men went peaceably to work again on Wednesday morning. The upward tendency of coal, arising out of European troubles is the cause of so easy and speedy a settlement.

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THE "Press" says that science has discovered almost as many uses for the common potato as there are chemical components in it. A foreign exchange describes a new mode of preparing wood-pulp for paper-making, which consists in using potatoes in lieu of alkaline solution usually employed to effect from poplar and other white-wood fibres the removal of gummy matter.

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IT is certainly a curious chemical fact that the substances required to form common table salt are both of them poisonous—chlorine and sodium. No one can use either of these articles separately with safety, and yet, combine them together and they form a substance necessary to health, and one found upon every table.

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ALL the locomotive works in Paterson, N. J., are busy at work; there is little prospect of a slackening up.

# COUNTERBRACING, AS A MEANS OF INCREASING THE RIGIDITY OF A BRIDGE TRUSS.

By E. SHERMAN GOULD, C. E.

In demonstrating the offices of the counterbrace in a straight truss, most authors base their calculations on the assumption that the web has no other duty to perform than to resist the shearing strain of the bridge and load.

In this sense, it is quite plain that counterbracing in *all* the panels is unnecessary, for those nearest the abutments of a long-span bridge can never be called upon to resist compression. This is evident without calculation, from the fact that the shearing strain is thrown *right* and *left* only from the *lowest point* of a deflecting truss. Now, the action of the weight of the bridge itself is to depress the structure in the *centre*, where the braces abut, and if an additional weight be applied somewhere between the centre and an abutment, that weight can only be transmitted *right* and *left*, on condition that its point of application be the lowest point of the curve which the bridge assumes. Hence, before the counter which abuts against the loaded brace can be compressed, the applied weight must be sufficient to raise the depressed centre of the bridge, or, in general terms, to change the curve of deflection due to the weight of the bridge itself.

It is evident, besides, that the more rigid the bridge, the earlier will the counterbracing be called upon. If the bridge were perfectly rigid and incompressible in all its parts, the counterbracing would be subject to be called upon in all the panels under an applied load.

But mere resistance to shearing is *not* the only function which the web has to perform. Rigidity is as indispensable to a permanent structure as strength, and this quality can only be obtained in a long-span truss by the proper arrangement of the members of the web.

When a train passes over a bridge, the bridge deflects more or less under the weight, and when the train has passed, it springs back *beyond* its previous static position, which it regains only after a series of vertical vibrations. These vibrations it is the aim of the bridge-builder to check—first, by reducing as far as possible the deflection, and, then, the upward spring. How is this double result to be accomplished? To answer this question it is necessary to investigate the manner in which the various members of the web-ties, braces and counters, react on each other.

Suppose we should construct a small model of an ordinary Howe truss, a few feet long, and some 4 to 6 in. deep, with square panels. If all the pieces were cut according to measurement, the model would come exactly together when put up. If, however, the braces be cut a little longer than 1.414 times the ties, they will have to be forced in, the effect of which will be to cumber up the truss in the middle, and compress the ties and counters. The whole system can thus be brought well into bearing. If now a weight be applied at the centre, or evenly distributed, the truss will sink a little and loosen the counterbraces. By inserting longer counters, or wedging up those already in, the truss will not spring back when the weight is removed, and will be as rigid as its form of construction admits of. Every member will be kept in bearing, and provision will thus be made to meet every change of form the truss may tend to assume.

All this which obtains in the case of a small model, holds good, more or less, in an actual bridge; and this I conceive to be the main office of the counterbrace, viz., to resist the back spring of the truss when relieved from the rolling load. A few experiments with the model, apart from all mathematical investigation, will show that, practically, counterbraces are very little needed anywhere in a truss to resist the direct shear of the load. In proportion, however, as they increase the rigidity of the truss, they bring themselves into play to resist the shear of the rolling load.

If the above view of the counterbraces be admitted, it will be seen that to insure good service from a bridge, it should be kept in adjustment, so that all its members may be constantly under strain, in order to avoid settling under a passing load.

In closing, I may add, in reference to the most economical form of truss, that

that would seem the best which, with a given amount of material, permits the widest separation of the flanges. Mere depth is an element of strength, entirely independent of the quantity of material used, and one which the bridge-builder should, therefore, endeavor by all means to obtain. The limit to the depth of any truss is the limit of the resistance of the compressive members of the web to lateral deflection; and attention should, therefore, be directed to such a disposition of these members as to secure for them the greatest length with the least deflection.

## WHAT IS ENERGY?

By BALFOUR STEWART.

From "Nature."

It is only of late years that the laws of motion have been fully comprehended. No doubt it has been known since the time of Newton that there can be no action without reaction; or, in other words, if we define momentum to be the product of the mass of a moving body into its velocity of motion, then whenever this is generated in one direction an equal amount is simultaneously generated in the opposite direction, and whenever it is destroyed in one direction, an equal amount is simultaneously destroyed in the opposite direction. Thus the recoil of a gun is the appropriate reaction to the forward motion of the bullet, and the ascent of a rocket to the downrush of heated gas from its orifice; and in other cases where the action of the principle is not so apparent, its truth has notwithstanding been universally admitted.

It has, for instance, been perfectly well understood for the last 200 years that if a rock be detached from the top of a precipice 144 ft. high it will reach the earth with the velocity of 96 ft. in a second, while the earth will in return move up to meet it, if not with the same velocity yet with the same momentum. But inasmuch as the mass of earth is very great compared with that of the rock, so the velocity of the former must be very small compared with that of the latter, in order that the momentum or product of mass into velocity may be the same for both. In fact, in this case, the velocity of the earth is quite insensible and may be disregarded.

The old conception of the laws of motion was thus sufficient to represent what takes place when the rock is in the act of traversing the air to meet the earth; but, on the other hand, the true physical concomitants of the crash which takes place when the two bodies have come together were entirely ignored. They met, their momentum was cancelled — that was enough for the old hypothesis.

So, when a hammer descends upon an anvil, it was considered enough to believe that the blow was stopped by the anvil; or when a break was applied to a carriage-wheel it was enough to imagine that the momentum of the carriage was stopped by friction. We shall presently allude to the names of those distinguished men who have come prominently forward as the champions of a juster conception of things, but in the meantime let us consider some of those influences which served to prepare men's minds for the reception of a truer hypothesis.

We live in a world of work, of work from which we cannot possibly escape; and those of us who do not require to work in order to eat, must yet in some sense perform work in order to live. Gradually, and by very slow steps, the true nature of work came to be understood. It was seen, for instance, that it involved a much less expenditure of energy for a man to carry a pound weight along a level road than to carry it an equal distance up to the top of a mountain.

It is not improbable that considerations of this kind may have led the way to a numerical estimate of work.

Thus, if we raise a pound weight 1 ft. high against the force of gravity, we may call it one unit of work; in which case 2 lbs. raised 1 ft. high or 1 lb. raised 2 ft. high would represent 2 units, and so on. We have therefore only to multiply the number of pounds by the vertical height in feet to which they are raised, and the product will represent the work done against gravity. The force of gravity be-

ing very nearly constant at the earth's surface, and always in action, is a very convenient force for this purpose; but any other force, such as that of a spring, would do equally well to measure work by. Generalizing, we may say, *the space moved over against a force multiplied into the intensity of that force will represent the quantity of work done.* So much for the definition of work, and it is necessary to know what *work* is before proceeding to define *Energy.*

Now what does the word Energy really mean? In the first place it does not mean force.

Two substances may have an intense mutual attraction, in virtue of which they form a very intimate union with one another; but when once this union is consummated, although the force continues to exist, the combination is singularly deficient in Energy. Nor does Energy mean motion, for although we cannot have motion without Energy, yet we may have Energy without motion.

*By the word Energy is meant the power of doing work;* and the energy which a laboring man possesses means, in the strictly physical sense, the number of units of work which he is capable of accomplishing.

This is a subject which at this stage we may attempt to illustrate by reference to a very different department of knowledge.

The analogy which we shall venture to institute is between the social and the physical world, in the hope that those who are more familiar with the former than with the latter may be led to perceive clearly what is meant by the word Energy in a strictly physical sense. Energy in the social world is well understood. When a man pursues his course, undaunted by opposition and unappalled by obstacles, he is said to be a very energetic man.

By his energy is meant the power which he possesses of overcoming obstacles; and the amount of this energy is measured (in the loose way in which we measure such things) by the amount of obstacles which he can overcome—the amount of work which he can do. Such a man may in truth be regarded as a social cannon-ball. By means of his energy of character he will scatter the ranks of his opponents and demolish their ramparts. Nevertheless, a man of this kind will sometimes be defeated by an opponent who does not possess a tithe of his personal energy. Now, why is this? A reply to this question will, if we do not mistake, exhibit in a striking manner the likeness that exists between the social and the physical world. The reason is, that, although his opponent may be deficient in personal energy, yet he may possess more than an equivalent in the high position which he occupies, and it is simply this position that enables him to combat successfully with a man of much greater personal energy than himself. If two men throw stones at one another, one of whom stands at the top of a house and the other at the bottom, the man at the top of the house has evidently the advantage.

So, in like manner, if two men of equal personal energy contend together, the one who has the highest social position has the best chance of succeeding. For this high position means energy under another form. It means that at some remote period a vast amount of personal energy was expended in raising the family into this high position. The founder of the family had, doubtless, greater energy than most of his fellows, and spent it in raising himself and his family into a position of advantage. The personal element may have long since disappeared from the family, but not before it had been transmuted into something else, in virtue of which the present representative is able to accomplish a great deal owing solely to the high position which he has acquired through the efforts of another. We thus see that in the social world we have what may justly be termed two kinds of energy, namely:—

1. Actual or personal energy.
2. Energy derived from position.

Let us now again turn to the physical world. In this as in the social world it is difficult to ascend. The force of gravity may be compared to that force which keeps a man down in the world. If a stone be shot upwards with great velocity, it may be said to have in it a great deal of actual energy, because it has the power of doing useful work, or of overcoming up to a great height the obstacle interposed by gravity to its ascent, just as a man of great energy has the power of overcoming obstacles. But this stone as it continues to mount upwards will do so with a gradually decreasing velocity, until at the sum-

mit of its flight all the actual energy with which it started will have been spent in raising it against the force of gravity to this elevated position. It is now moving with no velocity—just, in fact, beginning to turn—and we may suppose it to be caught and lodged upon the top of a house. Here, then, it remains at rest, without the slightest tendency to motion of any kind, and we are led to ask what has become of the energy with which it began its flight? Has this energy disappeared from the universe without leaving behind it any equivalent? Is it lost for ever, and utterly wasted?

To answer this we must learn to regard energy, not as a *quality*, but rather as a *thing*.

The chemist has always taught us to regard quantity or mass of matter as unchangeable, so that amid the many bewildering transformations of form and quality which take place in the chemical world, we can always consult our balance with a certainty that *it* will not play us false. But now the physical philosopher steps in and tells us that energy is quite as unchangeable as mass, and that the conservation of both is equally complete. There is, however, this difference between the two things—the same particle of matter will always retain the same mass, but it will not always retain the same energy. As a whole, energy is invariable, but it is always shifting about from particle to particle, and it is hence more difficult to grasp the conception of an invariability of energy than of an invariability of mass. For instance, the mass of our luminary always remains the same, but its energy is always getting less.

And now to return to our question—What has become of the energy of the stone? Has this disappeared? Far from it; the energy with which the stone began its flight has no more disappeared from the universe of energy, than the coal, when we have burned it in our fire, disappears from the universe of matter. But this has taken place—the energy has changed its form and become spent, or has disappeared as energy of actual motion, in gaining for the stone a position of advantage with regard to the force of gravity.

If we study this particular instance more minutely, we shall see that during the upward flight of the stone its energy of actual motion becomes gradually changed into energy of position, while the reverse will take place during its downward flight, if we now suppose it dislodged from the top of the house. In this latter case, the energy of position with which it begins its downward flight is gradually reconverted into energy of actual motion, until at last, when the stone reaches the ground, it has the same amount of velocity, and, therefore, of actual energy, which it had at first.

Let us now revert for a moment to the definition of energy, which means the power of doing work, and we shall see at once how we may gauge, numerically, the quantity of energy which the stone possesses; and in order to simplify matters, let us suppose that this stone weighs exactly 1 lb. If, therefore, it has velocity enough to carry it up 1 ft., it may be said to have energy enough to do one unit of work, inasmuch as we have defined 1 lb. raised 1 ft. high to be one unit of work; and in like manner if it has velocity sufficient to carry it 16 ft. high, it may be said to have an energy equivalent to 16 units of work or foot-pounds, as those units are sometimes called. Now, if the stone be discharged upwards with an initial velocity of 32 ft. per second, it will rise to 16 ft. high, and it has therefore an energy represented by 16. But if its initial velocity be 64 ft. per second, it will rise 64 ft. high before it turns, and will therefore have energy represented by 64. Hence we see that by doubling the velocity the energy is quadrupled, and we might show that by tripling the velocity the energy is increased 9 times. This is expressed in general terms by saying that the energy or quantity of work which a moving body can accomplish varies as the square of its velocity. This fact is well known to artillerymen, for a ball with a double velocity will penetrate much more than twice as far into an obstacle opposing its progress.

Let us now take the stone or pound weight, having an initial velocity of 64 ft. per second, and consider the state of things at the precise moment when it is 48 ft. high. It will at that moment have an actual velocity of 32 ft. per second, which, as we have seen, will represent 16 units of work. But it started from the ground with 64 units of work in it. What, therefore, has become of the difference—

or 48 units? Evidently it has disappeared as actual energy; but the stone, being 48 ft. high, has an energy of position represented by 48 units; so that at this precise moment of its flight its actual energy (16) *plus* its energy of position (48), are together equal to the whole energy with which it started (64).

Here, then, we have no annihilation of energy, but merely the transformation of it from actual energy into that implied by position; nor have we any creation of energy when the stone is on its downward flight, but merely the retransformation of the energy of position into the original form of actual energy.

We shall presently discuss what becomes of this actual energy after the stone has struck the ground; but, in the meantime, we would repeat our remark, how intimate is the analogy between the physical and the social world. In both cases we have actual energy and energy of position, the only difference being that in the social world it is impossible to measure energy with exactness, while in the mechanical world we can gauge it with the utmost precision.

Proteus-like, this element energy is always changing its form; and hence arises the extreme difficulty of the subject; for we cannot easily retain a sufficient grasp of the ever-changing element to argue experimentally regarding it. All the varieties of physical energy may, however, be embraced under the two heads already mentioned, namely, energy of actual motion and of position. We have chosen the force of gravity, acting upon a stone shot up into the air, as our example; but there are other forces besides gravity. Thus, a watch newly wound up is in a condition of visible advantage with respect to the force of the main-spring; and as it continues to go it gradually loses this energy of position, converting it into energy of motion. A cross-bow bent is likewise in a position of advantage with respect to the spring of the bow; and when its bolt is discharged, this energy of position is converted into that of motion. Thus again, a meteor, a railway train, a mountain torrent, the wind, all represent energy of actual visible motion; while a head of water may be classed along with a stone at the top of a house as representing energy of position. The list which represents visible energy of motion and of position might be extended indefinitely; but we must remember that there are also invisible molecular motions, which do not the less exist because they are invisible.

One of the best known of these molecular energies is *radiant light and heat*—a species which can traverse space with the enormous velocity of 186,000 miles a second.

Although itself eminently silent and gentle in its action, it is nevertheless the parent of most of the work which is done in the world, as we shall presently see when we proceed to another division of our subject. In the meantime, we may state that radiant light and heat are supposed to consist of a certain undulatory motion traversing an ethereal medium which pervades all space.

Now, when this radiant energy falls upon a substance, part of it is absorbed, and in the process of absorption is converted into *ordinary heat*. The undulatory motion which had previously traversed the thin ether of space has now become linked with gross palpable matter, and manifests itself in a motion which it produces in the particles of this matter. The violence of this rotatory or vortex-like motion will thus form a measure of the heat which the matter contains.

Another species of molecular energy consists of *electricity in motion*. When an electric current is moving along a wire, we have therein the progress of a power moving like light with enormous velocity, and, like light, silent in its operation. Silent, we say, if it meets with no resistance, but exceedingly formidable if it be opposed; for the awe-inspiring flash is not so much the electricity itself as the visible punishment which it has inflicted on the air for daring to impede its progress. Had there been a set of stout wires between the thunder-cloud and the earth, the fluid would have passed into the ground without disturbance.

The molecular energies which we have now described may be imagined to represent motion of some sort not perceived by the outward eye, but present nevertheless to the eye of the understanding; they may therefore be compared to the energy of a body in visible motion, or actual energy, as we have termed it.

But we have also molecular energies which are more analogous to the energy of position of a stone at the top of a cliff.

For instance, two bodies near one another may be endowed with a species of energy of position due to *opposite electrical states*, in which case they have a tendency to rush together, just as a stone at the top of a cliff has a tendency to rush to the earth. If the two bodies be allowed to rush together, this energy of position will be converted into that of visible motion, just as when the stone is allowed to drop from the cliff, its energy of position is converted into that of visible motion.

There is, finally, a species of molecular energy caused by *chemical separation*. When we carry a stone to the top of a cliff, we violently separate two bodies that attract one another, and these two bodies are the earth and the stone. In like manner, when we decompose carbonic acid gas into its constituents, we violently separate two bodies that attract one another, and these are carbon and oxygen. When, therefore, we have obtained in a separate state two bodies, the atoms of which are prepared to rush together and combine with one another, we have at the same time obtained a kind of energy of molecular position analogous on the small scale to the energy of a stone resting upon the top of a house, or on the edge of a cliff, on the large or cosmical scale.

### THE CONSERVATION OF ENERGY.

It is well-known that certain organisms of the animal world do not confine themselves to one state of being or to one order of existence, and the most familiar instance of this roving habit of life is the caterpillar, which passes first into the chrysalis state, and after that into the butterfly. This habit is not, however, peculiar to the organic world, for energy delights in similar transmutations, and we have just seen how the eminently silent and invisible electrical current may occasionally be transmuted into the vivid, instantaneous, awe-inspiring flash of lightning. Nor is this element of change confined to our peculiar corner of the universe, but it extends itself to remote starry systems, in some of which there is a total extinction of luminosity for a while, to be succeeded by a most brilliant luminous outburst, presenting all the appearance of a world on fire.

We shall not enter here into great detail regarding the various changes of energy from one form into another; suffice it to say, that amid all these changes of form, and sometimes of quality, the element of *quantity* remains the same. Those of our readers who are mathematicians know what is meant by variable quantities; for instance, in the equation $x + y + z = A$, if $x$, $y$, & $z$ are variable and A constant, you may change $x$ into $y$ and into $z$, and $y$ into $x$ and into $z$, and in fact perform any changes you choose upon the left hand side of your equation, *provided that* you keep their sum always constant and equal to A. It is precisely thus in the world of energy; and the invariability of the sum of all the energies af the universe forms the doctrine known as the "conservation of energy." This doctrine is nothing else than an intelligent and scientific denial of the chimera of perpetual motion.

Recognizing the great importance of work, it was natural enough at an early stage of our knowledge that enthusiasts should endeavor to create energy or the power of doing work, that is to say, endeavor to construct a machine that should go on working for ever without needing to be supplied with fuel in any way, and accordingly inventors became possessed with the idea that some elaborate system of machinery would, no doubt, give us this grand desideratum, and men of science have been continually annoyed with these projects, until in a moment of inspiration they conceived the doctrine of the conservation of energy!

It flows from this doctrine that a machine is merely an instrument which is supplied with energy in one form, and which converts it into another and more convenient form according to the law of the machine.

We shall now proceed to trace the progress of energy through some of its most important transformations. To begin with that one to which we have already alluded, what becomes of the energy of a falling body after it strikes the earth? This question may be varied in a great number of ways. We may ask, for instance, what becomes of the energy of a railway train after it is stopped? What becomes of the energy of a hammer after it has struck the anvil? of a cannon ball after it has struck the target? and so on.

In all these varieties we see that either percussion or friction is at work; thus it is friction that stops a railway train, and

it is percussion that stops the motion of a falling stone or of a falling hammer, so that our question is in reality, what becomes of the energy of visible motion when it has been stopped by percussion or friction?

Rumford and Davy were the pioneers in replying to this important question. Rumford found that in the process of boring cannon the heat generated was sometimes so great as to boil water, and he supposed that work was changed into heat in the process of boring. Davy again melted two pieces of ice by causing them to rub against each other, and he likewise concluded that the work spent on this process had been converted into heat.

We see now why by hammering a coin on an anvil we can heat it very greatly, or why on a dark night the sparks are seen to fly out from the break-wheel which stops the motion of the railway train, or why by rubbing a metal button violently backwards and forwards against a piece of wood we can render it so hot as to scorch our hand, for in all these cases it is the energy of visible motion which is being converted into heat.

But although this was known nearly a century ago, it was reserved for Joule, an English philosopher of the present day, to point out the numerical relation subsisting between that species of energy which we call visible motion and that which we call heat.

The result of his numerous and laborious experiments was, that if 1 lb. of water be dropped from a height of 772 ft. under the influence of gravity, and if the velocity which it attains be suddenly stopped and converted into heat, this heat will be sufficient to raise the whole mass 1 deg. Fahr. in temperature.

From this he concluded that when 1 lb. of water is heated 1 deg. Fahr. in temperature, an amount of molecular energy enters into the water which is equivalent to 772 foot-pounds, that is to say, to 1 lb. raised 772 ft. high against the influence of gravity, or allowed to fall 772 ft. under the same influence.

He found again that if 1 lb. of water were to fall twice this distance, or 1,544 ft. under gravity, the velocity if stopped would raise its temperature 2 deg. Fahr., and in fact that the rise of temperature under such circumstances is proportional to the height from which the 1 lb. of water is supposed to fall. By this means an exact relation is established between heat and work. Grove was the first to point out the probability of a connection between the various species of molecular energy; and the researches of Joule, Thomson and others, have established these relations with numerical accuracy. No better example of the correlation of the various kinds of energy can be given than what takes place in a galvanic battery. Let us suppose that zinc is the metal used. Here the source of energy is the burning or chemical combination of the zinc with oxygen, etc., in order to form a salt of zinc. The source of energy is in fact much the same as when coal is burned; it is the energy produced by chemical combination. Now, as we have said, the zinc combines with the oxygen, and sulphate of zinc is produced, but the result of this combination does not at first exhibit itself in the form of heat, but rather in that of an electric current. No doubt a great portion of the energy of this electric current is ultimately spent in heat, but we may, if we choose, spend part in promoting chemical decomposition; for instance, we may decompose water. In this case part of the energy of the battery, derived as has been stated from the burning of the zinc, is spent in heat and part in decomposing the water, and hence we shall have less heat than if there were no water to decompose. But if when we have decomposed the water, we mix together the two gases, hydrogen and oxygen, which are the results of this decomposition, and explode them, we shall recover the precise deficiency of heat. Without the decomposition, let us say that the burning in the battery of a certain weight of zinc gives us heat equal to 100, but with the decomposition only 80; 20 units of energy have therefore become spent in the decomposition, but if we explode the mixture of gases procured from the decomposition we shall get back heat equal to 20, and thus make the whole result of the burning of the zinc 100 units of energy as before.

In like manner, if our electric battery is made to do work, thus forming a kind of engine, we shall have the heat produced by the current diminished by the exact equivalent of the mechanical effect which we have obtained from this engine.

There is nothing for nothing in the universe of energy.

At this point we can imagine some champion of perpetual motion coming forward and proposing conditions of truce. "I acknowledge," he will say, "that perpetual motion, as you have defined it, is quite impossible, for no machine can *create* energy, but yet I do not see from your own stand-point that a machine might not be constructed that would produce work for ever. You tell me, and I believe you, that heat is a species of molecular motion, and hence that the walls of the room in which we now sit are full of a kind of invisible energy, all the particles being in rapid motion. Now, may we not suppose a machine to exist which converts this molecular motion into ordinary work, drawing first of all the heat from the walls, then from the adjacent air; cooling down, in fact, the surrounding universe, and transforming the energy of heat so abstracted into good substantial work? There is no doubt work can be converted into heat—as, for instance, by the blow of a hammer on an anvil—why, therefore, cannot this heat be converted back again into work?"

We reply by quoting the laws discovered by Carnot, Clausius, Thomson, and Rankine, who have all from different points of view been led to the same conclusion, which, alas! is fatal to all hopes of perpetual motion. We may, they tell us, with the greatest ease convert mechanical work into heat, but we cannot by any means convert all the energy of heat back again into mechanical work. In the steam-engine we do what can be done in this way; but it is a very small proportion of the whole energy of the heat that is there converted into work, for a large portion is dissipated, and will continue to be dissipated, however perfect our engine may become. Let the greatest care be taken in the construction and working of a steam-engine, yet shall we not succeed in converting $\frac{1}{4}$ of the whole energy of the heat of the coals into mechanical effect.

In fact, the process by which work can be converted into heat is not a completely reversible process, and Sir W. Thomson has worked out the consequences of this fact in his beautiful theory of the dissipation of energy.

As far as human convenience is concerned, the different kinds of energy do not stand on the same footing, for we can make great use of a head of water, or of the wind, or of mechanical motion of any kind, but we can make no use whatever of the energy represented by equally diffused heat. If one body is hotter than another, as the boiler of a steam-engine is hotter than its condenser, then we can make use of this difference of temperature to convert some of the heat into work, but if substances are equally hot, even although their particles contain an enormous amount of molecular energy, they will not yield us a single foot-pound of work.

Energy is thus of different *qualities*, mechanical energy being the best, and universal heat the worst; in fact, this latter description of energy may be likened to the dreary waste heap of the universe, in which the effete forms of energy are suffered to accumulate; and, alas! this desolate waste heap is always continuing to increase. But before attempting to discuss the probable effect of this process of deterioration upon the present system of things, let us look around us and endeavor to estimate the various sources of energy that have been placed at our disposal.

To begin with our own frames, we all of us possess a certain amount of energy in our systems, a certain capacity for doing work. By an effort of his muscles the blacksmith imparts a formidable velocity to the massive hammer which he wields; now what is consumed in order to produce this? We reply, the tissues of his body are consumed. If he continues working for a long time he will wear out these tissues and nature will call for food and rest; for the former, in order to procure the materials out of which new and energetic tissues may be constructed; for the latter, in order to furnish time and leisure for repairing the waste. Ultimately, therefore, the energy of the man is derived from the food which he eats, and if he works much, that is to say, spends a great deal of energy, he will require to eat more than if he hardly works at all. Hence it is well understood that the diet of a man sentenced to imprisonment with hard labor must be more generous than that of one who is merely imprisoned, and that the allowance of food to a soldier in the time of war must be greater than in time of peace.

In fact, food is to the animal what fuel

is to the engine ; only an animal is a much more economical producer of work than an engine. Rumford justly observed that we shall get more work out of a ton of hay if we give it as food to a horse than if we burn it as fuel in an engine. It is in truth the combustion of our food that furnishes our frames with energy, and there is no food capable of nourishing our bodies which, if well dried, is not also capable of being burned in the fire. Having thus traced the energy of our frames to the food which we eat, we next ask whence does this food derive its energy? If we are vegetarians we need not trouble ourselves to go further back, but if we have eaten animal food and have transferred part of the energy of an ox or of a sheep into our own systems, we ask, whence has the ox or the sheep derived its energy, and answer, undoubtedly from the food which it consumes, this food being a vegetable. Ultimately, then, we are led to look to the vegetable kingdom as the source of that great energy which our frames possess in common with those of the inferior animals, and we have now only to go back one more step and ask whence vegetables derive the energy which they possess?

In answering this question, let us endeavor to ascertain what really takes place in the leaves of vegetables. A leaf is, in fact, a laboratory in which the active agent is the sun's rays. A certain species of the solar ray enters this laboratory, and immediately commences to decompose carbonic acid into its constituents oxygen and carbon, allowing the oxygen to escape into the air while the carbon is, in some shape, worked up and assimilated. First of all, then, in this wonderful laboratory of Nature, we have a quantity of carbonic acid drawn in from the air ; this is the raw material. Next, we have the source of energy, the active agent ; this is light. Thirdly, we have the useful product ; that is, the assimilated carbon. Fourthly, we have the product dismissed into the air, and that is oxygen.

We thus perceive that the action which takes place in a leaf is the very reverse of that which takes place in an ordinary fire. In a fire, we burn carbon, and make it unite with oxygen in order to form carbonic acid, and in so doing we change the energy of position derived from the separation of two substances having so great an attraction for each other as oxygen and carbon, into the energy of heat. In a leaf, on the other hand, these two strongly attractive substances are forced asunder, the powerful agent which accomplishes this being the sun's rays, so that it is the energy of these rays which is transformed into the potential energy or energy of position represented by the chemical separation of this oxygen and carbon. The carbon, or rather the woody fibre into which the carbon enters, is thus a source of potential energy, and when made to combine again with oxygen, either by direct combustion or otherwise, it will in the process give out a deal of energy. When we burn wood in our fires we convert this energy into heat, and when we eat vegetables we assimilate this energy into our systems, where it ultimately produces both heat and work. We are thus enabled to trace the energy of the sun's rays through every step of this most wonderful process ; first of all building up vegetable food, in the next place feeding the ox or sheep, and lastly through the shape of the very prosaic but essential joint of beef or mutton entering into and sustaining these frames of ours.

We are not, however, quite done yet with vegetable fibre, for that part of it which does not enter into our frames may, notwithstanding, serve as fuel for our engines, and by this means be converted into useful work. And has not Nature, as if anticipating the wants of our age, provided an almost limitless store of such fuel in the vast deposits of coal by means of which so large a portion of the useful work of the world is done? In geological ages this coal was the fibre of a species of plant, and it has been stored up as if for the benefit of generations like the present.

But there are other products of the sun's rays besides food and fuel. The miller who makes use of water-power or of wind-power to grind his corn, the navigator who spreads his sail to catch the breeze, are indebted to our luminary equally with the man who eats meat or who drives an engine. For it is owing to the sun's rays that water is carried up into the atmosphere to be again precipitated so as to form what is called a head of water, and it is also owing to the sun's heat that winds agitate the air. With the trivial exception of tidal energy, all

the work done in the world is due to the sun, so that we must look to our luminary as the great source of all our energy.

Intimately linked as we are to the sun, it is natural to ask the question, Will the sun last forever, or will he also die out? There is no apparent reason why the sun should form an exception to the fate of all fires, the only difference being one of size and time. It is larger and hotter, and will last longer than the lamp of an hour, but it is nevertheless a lamp. The principle of degradation would appear to hold throughout, and if we regard not mere matter but useful energy, we are driven to contemplate the death of the universe. Who would live for ever even if he had the elixir of life? or, who would purchase, if he might, the dreary privilege to preside at the end of all things—to be "twins in death" with the sun, and to fill up in his own experience the melancholy dream of the poet:

> The sun's eye had a sickly glare,
> The stars with age were wan,
> The skeletons of nature were
> Around that lonely man.
> Some died in war, the iron brands
> Lay rusting in their bony hands;
> In peace and famine some.
> Earth's cities had no sound nor tread,
> And ships lay drifting with their dead
> To shores where all were dumb.

## CIVIL ENGINEERING AT THE TIME OF CHRIST.

From "The Railway Journal and Mining Register."

The Roman genius for construction was the grandest the world has seen. The traveller visits the cathedral fanes of York and Bourges, Burgos and Seville, Cologne and Milan, the castles of Windsor and Heidelberg and S. Elmo, the temples at Pæstum, at Athens, at Baalbec, and at Thebes, the palaces of the Maharajahs, on the banks of the Ganges, sees monuments of splendid beauty, unsurpassed in any age, by any people; yet he returns to Rome, and says, while standing upon the vaulted ruins of the baths of Caracalla or while counting his steps across the floors of Constantine's Basilica, or while looking down from the utmost tier of seats into the arena of the Coliseum, that the constructive genius of all the rest of the world must bend before the Imperial Latin Engineer.

Never but once were thus combined in the political situation of a city all elements needful for carrying up the culture of mere building talent to the highest pitch, while at the same time were offered unlimited opportunities for its exercise. Rome was a seaport, backed by a country fertile in supplies, a peninsula of mountains made of marble, in the centre of a vast sea, crowded with well-settled islands, and girt about with coasts inhabited by the oldest and most advanced communities of man. The Roman States were still physically undebauched; in the prime of its strength; irresistible lord of all the Western and half the Eastern world; was infinitely rich; irresponsible and unscrupulous; proud and vain; sensual and sensational; loving war only for the sake of its fruits, and preferring peace for the sake of its enjoyments. The Bath-house was the church of Rome, combining the essential qualities of the Exchange, the Club, the Museum, the Bar-room, and the Polls. The Emperors enriched themselves and confirmed their power by watering their political stock. Caracalla could afford his horse a golden manger in a temple of its own, after affording his fellow-citizens a Bagnio as large as the Tuileries, in which 10,000 bathers could enjoy themselves at once, the ceilings of which were 80 ft. high, the partition walls as massive as the abutments of a bridge. The sweating-room alone was larger than the Catholic Cathedral in Philadelphia, and surrounded by arcades, inside, of costly Corinthian columns, the abstraction of which by the mediæval princes of modern Rome for use in the construction of their private palaces brought down the ceiling with a crash which shook the city as far off as the Castle of S. Angelo.

S. Peter's is built on the model of these ancient monuments. Its nave is precisely of the size and shape of the great room in the Baths of Diocletian, and of the name of Constantine's great church. Its dome is precisely the size and shape of the Pantheon, which, as is now well-known, was yet another Imperial Bath-room, since then appropriated to the uses of religion

—merely a change from hot to holy water. The great Bath-room of Diocletian is also one of the grandest churches of modern Rome. The necessity for supplying an amphibious population with floods of fluid developed the civil engineering talents of the Empire. Scores of aqueducts were constructed above ground to bring the waters of the Appenines into the city, and an elaborate system of sewerage carried it away again to be re-purified in the bosom of the Ligurian sea. While Signor de Rossi has been excavating the ancient catacombs outside the walls, and the Government antiquarian, Baron Visconti, the ancient marble yards and police stations inside the walls, and the Emperor Napoleon the foundation rooms of the Palace of the Cæsars, the British Archæological Society of Rome has been digging along the foundations of the ancient walls themselves, and opening up the underground water-works, reservoirs, and sewers of ancient days. They have determined the true site of the fountain of Egeria and of King Numa's Palace; how Royal Rome, Republican Rome, Imperial Rome were in succession fortified with longer and larger circumvallations; and how the water pipes of the engineers of the Middle Ages were ranged within and upon the conduits of Servius Tullius and the Tarquins. Any civil engineer who is curious in such matters, or would like to see nice pictures of the rubble work of his predecessors in the profession twenty-two centuries ago, can gratify himself by looking over Mr. Parker's "Notices of Recent Excavations in Rome," just published in Part I. of the forty-second volume of the "Archæologia." By the by, Mr. Parker's little hand-books of architecture are not only indispensable for the tourist, but ought to be in every American gentleman's library. And it is worth knowing, also, that the Archæological Society, which the foreigners in Rome keep up, has upwards of a thousand special photographs of specimens of Roman construction, arranged in the order of time.

The first part of this interesting collection is already for sale, and illustrates the historical construction of walls in a series of sixty-four samples, beginning with the wall of Romulus, 750 B. C., and taking on the average one for each generation. The series is continued down to the 13th century A. D. In the time of the Empire the dated examples are so numerous that they are necessarily subdivided; afterwards the churches and monasteries supply us with a continuation of the series. This is really a great work for the history of architecture, such as has never been done before. Even D'Agincourt, in his admirable work, overlooks construction, which is the foundation of all. It is sometimes impossible to get photographs from nature from want of sufficient space, and it is generally necessary to fill up the excavations again immediately, so that plans and drawings are the only mode of showing what has been made out; but photographs are made of these and sent to the Oxford Architectural Society.

## THE FAIRLIE ENGINE.

From "The Railway News."

Mr. Robert Fairlie certainly deserves success, and we have pleasure in believing that he is commanding it. On Thursday last and yesterday in the little "cabbage garden" at Hatcham another of his great triumphs was exhibited in the trial of the "Tarapaca," a double bogie locomotive of 60 tons weight, coaled and watered, destined for Peru. The experiments were witnessed by some hundreds of eminent official and scientific men, who were all in accord, in so far as we could hear, in their admiration of the new engine, which for hours in succession performed the feat, smoothly and with perfect success, of turning round the oval in the gardens, the end curves being of only 50 ft. radius. The railway world has heard of Mr. Fairlie's "Little Wonder" at work upon the Festiniog Railway, and of the triumphs of the "Progress" on the Brecon and Merthy Railway. The "Tarapaca" may properly be designated the "Great Wonder," in the adaptation of steam power to locomotive purposes. As stated, the engine is 60 tons weight in working order, or 40 tons weight when empty; the bunker room is sufficient for 30 cwt. of fuel, and the tank accomodation is for 2,200 gals. of water, which should suffice for a 60 miles run.

The weight is equally distributed upon 12 wheels, in 2 groups of 6 each. The wheels in each group are coupled together, so that all the twelve are driving wheels, and the whole of the 60 tons is thus made available for adhesion. The "Tarapaca" will have to work a gradient of 1 in 26 for 11 miles on the Iquiqui line in Peru, belonging to MM. Montero Frères. The engine has 4 cylinders of 15 in. diameter and 20 in. stroke. The wheels are 3 ft. 6 in. in diameter, and the break arrangement, very powerful, is applied to the 4 inner wheels of the 12. The force of the engine at the rails is about 21,400 lbs., or 9½ tons, and equal to hauling a load of 2,000 tons, on the level, at a speed of 12 miles an hour.

The "Little Wonder" runs upon a gauge of 1 ft. 11½ in.; the "Tarapaca" is made for the ordinary 4 ft. 8½ in. gauge. The Fairlie engine can double the capabilities of any line, irrespective of gauge, its power being double that of engines of the ordinary type. The Festiniog gauge is unduly narrow, and the ordinary 4 ft. 8½ in gauge is wider than is necessary to realize the maximum advantages of the Fairlie system, which may be secured with a gauge of from 3 ft. to 3 ft. 6 in. A 3 ft. gauge line worked upon this system may be made to carry as many passengers and as many tons of goods as the broadest gauge line in existence, and it can be worked in the ordinary manner, at a speed of from 40 to 45 miles an hour. The dead weight on narrow gauge lines is much less proportionately than on broad gauge lines. A wagon for a 3 ft. gauge, weighing 1 ton, will carry 3 tons of paying weight. The best form of wagon on a 4 ft. 8½ in. gauge weighs from 3 to 5½ tons, and carries from 5 to 10 tons, or about 1.90 ton per ton of wagon. The average load carried by merchandise wagons, exclusive of coal, is about 10 cwt. paying weight. The load these wagons ought to carry should be from 5 to 7 tons; of paying load they really carry but a twelfth of what they ought to do. If our goods and mineral wagons were only a ton in weight, as they ought to be, they would carry 3 tons of load, or 6 times the average load now taken, and would reduce the dead weight from 4 to 1. A railway company that we forbear from naming, carries over its line 126,000,000 tons per annum, out of which it takes payment for only 15,000,000 tons of paying load. Fairlie's narrow gauge and 1 ton wagon system would reduce this gross tonnage one-half, thus saving the company the cost of hauling 60,000,000 tons per annum of dead weight. The experts who attended the trials at Hatcham on the last two days were agreed as to the entire absence of oscillation in the movements of the engine. The ordinary locomotive, it is well known, increases its oscillation, as it increases its speed, and *ipso facto* increases the power and effect of the blows inflicted upon the rails. The oscillations of the engines are communicated to the trains they draw, and danger is thus increased. The Fairlie engine, it has been fully demonstrated, runs more smoothly and faster without the pounding of the rails caused by the engines of the ordinary type.

From all that we have seen of Mr. Fairlie's Big and Little Wonders in his double bogie engines for any gauge, but preferably for a gauge of say 3 ft., we cannot doubt that the adoption of his inventions would revolutionize railway working and make the difference, as regards railway property, that there is between wasted money and lucrative investments. Ere long, notwithstanding the *vis inertiæ* of the directorial mind, we have little doubt that we will have English companies sharing with Russian, Peruvian, and Welsh mine-masters, in the benefits that Mr. Fairlie and his double bogie system are ready to confer upon them.

An engine on the Fairlie principle has recently been completed in the United States, adapted to the roads of that country. It is thus described by the "Springfield Republican:"—"The memory of that mythical divinity, the two-faced god, Janus, is perpetuated in a double-headed locomotive, built by Mason, of Taunton, after a style invented by Robert Fairlie, of England. This ponderous and unique machine, which is to become the property of the Boston and Albany Railroad, drew hither from Worcester the other day 40 freight cars, half of which were loaded. It would have drawn more had not the pump given out—a defect easily remedied and by no means vital. It will speedily be repaired, and the machine sent on a trial trip up the hills to Pittsfield immediately. This dual engine has 1 boiler with 2 heads, and at each end rests on 6 drive wheels. The

cab rests on the boiler, over the centre, where 1 lever lets on the steam. The water tanks and bunkers for coal are above the boilers on each side of the cab. In going in one direction one-half of the locomotive is going ahead and the other backing, and the latter goes ahead when the steam is reversed, and the other half backs.

"Thus the necessity of turn-tables is avoided, and it is claimed that the same amount of steam in such an engine will accomplish more than in one of the ordinary kinds."

## THE INDIAN BUDGET.

From "The Engineer."

From the Budget statement of the Indian Finance Minister, on 1st April last, we learn particulars regarding the expenditure actually incurred upon public works in India during the past year, as well as the contemplated expenditure for the ensuing 12 months. It is, however, from the speech of his Excellency the Viceroy, who, as member of the Council of India, has special charge of the Public Works Department, that we derive most interesting information on the subject. Since the Indian Public Works Department is for the most part recruited by engineers from England, the amount to be annually expended upon works in India is of great moment to members of the profession in this country.

The total estimated expenditure on public works in England and India in 1869–70 has amounted in round numbers to about £8,000,000, divided into ordinary expenditure £5,300,000, and extraordinary £2,600,000. Of the sum devoted to ordinary expenditure £5,000,000, as nearly as possible, have been spent upon public works, the residue being spent upon railways and loss by exchange. The extraordinary expenditure was made up of £2,000,000 spent on irrigation works, and a small sum on State railways. The principal items of ordinary expenditure were as follows:—Military works, nearly £1,500,000, divided into original works £1,200,000, and repairs £297,000; agricultural works, £478,000, divided into £192,000 for original works, and £279,000 for repairs; civil buildings, £680,000, of which £562,000 were for original works, and £122,000 for repairs; communications, including the construction and repair of ordinary roads, £1,000,000, of which £600,000 has been spent upon original works, and £400,000 on repairs; miscellaneous and public improvements, £58,000; establishment, £1,000,000, and £70,000 for tools and plant. Of the million and a half spent upon extraordinary works, £950,000 went for irrigation, £144,000 for State railways, and £360,000 for the Bombay Special Fund. The expenditure for the current year is placed at £7,475,000, of which £6,900,000 will be expended in India, and £500,000 in England. The ordinary expenditure is fixed at £4,300,000, of which £3,900,000 will be spent upon public works; and the extraordinary expenditure at £3,100,000. Under the head of military works, the total sum to be spent in 1870–71 is £913,000 on original works, and £214,000 on repairs. The bulk of the sum assigned for "accommodation of troops" will be spent on barracks for Europeans and the improvement of unhealthy stations. Other branches of expenditure will be ordnance factories, gas works, water supply, and defences. The most important defences will be Bombay Harbor and Rangoon Pagoda. Under the head of civil works, one of the principal grants, £26,500, will be made to the Kurrachee Harbor; but the Government is inquiring whether these works could not be completed by a local trust. The grant for the Godavery navigation works is fixed at £30,500; that for the road from Dharwar to Carwar, at £15,000; Bombay Harbor improvements, at £147,500, which will be debited against the proposed port trust; Madras jails, £9,768; and the Calcutta High Court, a final grant of £40,000. The Imperial Museum and Calcutta University are set aside for the present. The ordinary grant for agricultural works for the past year was £478,279, of which £192,199 were for new works, £279,580 for repairs, and £6,500 for State outlay on guaranteed works. The extraordinary grant was originally £1,650,000, but the expenditure

is not likely to exceed £900,000. For 1870–71, ordinary works are set down at £497,300, and extraordinary works £1,732,500, making a grand total allotment for irrigation works of £2,229,800, of which £1,415,820 will be for actual construction of new works, and £322,500 for repairs. The greater part of the ordinary grant will be devoted to repairs, from the necessity of maintaining in good working order the extensive system of irrigation works already in operation. The allotment for the irrigation works in the Godavery and Kistua Deltas is £52,760. In Bombay £545,494 has been sanctioned for extraordinary agricultural works, of which £305,898 will be spent upon a reservoir and canal at Poona. A canal from Roree, on the Indus, to Hyderabad, will probably be commenced during the year. In Bengal, works in Orissa, on the Soane, and the Gunduk are in operation; in the North-West, additions to the Ganges Canal, a canal from the Jumna, near Delhi, to Agra, and a system of similar canals in Rohilcund, and a scheme for irrigating Eastern Rohilcund, by a canal from the Ganges at a cost of £1,000,000, is before Government. In the Punjab, the Baree Doab Canal is in progress, and the Kussoor and Sobraon branches have been recommended for construction, at an estimated cost of £270,000. The Sirhind Canal has also been commenced on an estimate of £2,250,000. The year 1870–71 will be a notable year in the railway history of India. On the 31st December, 1869, there were open in India 4,264 miles of railway, and it is expected that 5,061 miles will be open on the 31st December, 1870, or at all events before the close of the current financial year, so that it is hoped an addition will be made during the year to the railway system of India of 801 miles. Of this the Great Indian Peninsula Railway has recently opened 238½ miles of the north-east extension, and 158½ miles of the southern will shortly be opened. The north-west extension of the Madras Railway will open 94¼ miles, and the Bellary branch of the same line 32 miles; Khamgaon Railway, 7½ miles; Oomrawuttee, 5 miles; and Delhi, 32½ miles. The East India Railway will open its Chord line of 123½ miles, and the same company the Kurhurbaree branch of 24½ miles. The Eastern Bengal Railway will open the Goalundo extension of 45 miles, and the Oude and Rohilcund Railway the line to Byrom Ghat, 40 miles, making altogether a total of 801 miles, which is the greatest number of miles ever opened in India in any one single year. Sir Salar Jung has already made financial arrangements to construct a branch line from Goolburga to Hyderabad entirely at the expense of the Hyderabad State; the Maharajah of Holkar has also agreed to lend the Government, at 4½ per cent., a million of money to construct a line which will meet the Great Indian Peninsula system somewhere near Khundwa.

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Peter Myers, of Cherry Hill, Indiana county, recently found a vein of iron ore on his farm, which he has followed to the depth of 12 feet, and has not yet found the bottom. It is pronounced a good quality of ore, and will doubtless prove a valuable discovery, should the quantity hold out.

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J. L. Booth, of Rochester, N. Y., has invented a new rail which consists of a compound formed by first rolling the cap and base separately and then applying them together and passing them together through a rolling or compressing machine, whereby they are firmly united and without being heated for the purpose.

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By means of its magnificent diversified industry, mainly of iron, in its different departments, the farmer of Berks county, Pennsylvania, has at all times a market within the borders of his own county for all his produce, and the demand is actually in excess of the supply.

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A silver mine of unparalleled richness has been discovered in Greyson county, Kentucky. The ore was found to contain a larger per cent. of silver than any hitherto discovered. The mines are almost inexhaustible, and will soon be developed.

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Corry manufactures 1,800 pails, and 750 tubs per day.

# THE EVAPORATING CAPACITY OF BOILERS HEATED BY WASTE HEAT FROM PUDDLING FURNACES.

By J. H. RADINGER.*

From "The American Railway Times."

Boilers exposed to the waste heat of puddling or boiling furnaces, evaporate much more water in proportion to the heated surface, than those heated by common means. To gain a positive basis for the necessary capacity of the feeding-pumps to the boilers of the new additions to the rolling-mills of Count Henkel von Donnersmark, near Vienna, I lately made, on invitation of the manager, observations on the amounts of evaporated water in older boilers with the above heating arrangement, for which purpose I proceeded as follows: The three boilers on which observations were to be made simultaneously, are arranged behind three re-heating furnaces standing side by side, in a straight line, between the slag-hole and the chimney. The masonry reaches in front up to a height equal to the horizontal diameter, and the boiler is inclined towards its back part 4 in., while the line of the flue-bottom below remains horizontal. The circular front surface of the boilers is covered by a wall, in order to prevent the flame touching the joints and rivets of the plates. These three boilers, each of which is 22 ft. (6.95 metres) long and 3½ ft. (1.1 metres) in diameter, and which consequently possess a combined heating surface of 400 sq. ft. (40 sq. metres), were all fed by one pump from a cast-iron reservoir, 30 in. in depth, the vertical walls of which surround a surface of water of 9.35 cubic ft. An inserted rule indicated the falling of the level during each feeding operation, and as, according to a simple calculation, 1 in. lowering of the level is equal to a volume of 0.77 cubic ft., the determination of the consumed quantity of water was easy and accurate.

To establish, at the same time, the useful effect of the feeding-pump (in order to enable the managers in the future to make such a measurement approximately, but in a much simpler manner), an apparatus recording the rotations was affixed to the shaft of the fly-wheel. And as the plunger has a diameter of 2 in. 5½ lines (65 m. m.), a stroke of 8 in. 1½ lines (215 m. m.) and every 100 strokes of the plunger are equivalent to a theoretical space of 2½ cubic ft.; 80 to 85 strokes were made per minute, which is equivalent to 2 ft. (0.63 metres) velocity of plunger; the height of suction was in the mean 3½ ft. (1.1 metre).

To ascertain, furthermore, the relations between the coal burnt and the water evaporated, for the purpose of comparison with other kinds of coal, we concluded to try the experiment until the known contents of a coal wagon (170 zoll-centner, or 8,500 kilogrammes) should be consumed by the three boilers. But our intentions, as far as the last-mentioned condition is concerned, had to be given up for two reasons: First, the feeding pump proved a little too weak, as it could not keep up a proper supply of water, because it had to be stopped every time during the refilling of the reservoir (the influx being continuous at ordinary times). On account of this circumstance, the three boilers contained, after 6¼ hours, 26 cubic ft. less water than at the commencement of the experiment—a fact which could be established with sufficient accuracy by the water-gauges and accurate drawings of the boilers. In the second place, the experiment was necessarily limited by an accident, the breaking of a screw in the eccentric of the rolling machine, during the repairing of which the fires under the boilers had to be smothered. The remaining coal was weighed, and found to be 30 zoll-centner; the weight of the coal burnt (from Domboan, Upper Silesia) was consequently 140 zoll-centner (7,000 kilogrammes).

With the burning of this coal and the determination of the water level, we commenced experiment No. 5 at 9.33 A. M. The first four observations were for the training of the workmen and the control of the apparatus. In experiment No. 1, for instance, a comparison of the water really introduced with the volume traversed by the plunger, showed the relation of 43:100, and by this discrepancy our attention was drawn to a small, almost

* Zeitschrift des Oestereichischen Ingenieur and Architecten Vereins.

invisible crack in an elbow of the suction-pipe, which permitted the entrance of air, and had therefore to be stopped. The indications of the hand attached to the rotation-counter must, of course, only be noticed from the time the pump catches water. If there is air in the suction-pipe, which is always the case after a stoppage for some time, the rising of the water inside can easily be followed with a hammer, a rap on the portion of the pipe containing water sounding entirely different from one on the part containing only air. And when the hand is held to the valve-box, after the water has filled the whole suction-pipe, the stroke, during which the valve falls the first time on its seat surrounded by water, can be distinctly recognized. This was always the first stroke counted.

I must also premise that the observations were intentionally made in the middle of the week (Wednesday, Sept. 15, 1869), when the masonry was at an average temperature; that the weather was clear, and the direction of the weak currents of wind was from the grate-bars to the chimney—a fact which facilitates considerably the draft and the maintenance of an even pressure of steam. The experiment lasted from 8.24 A. M. to 3.48 P. M., and as two shifts work through the week, there can be no doubt that the conditions under which we experimented remained the same throughout. For these reasons, I am of opinion that the experiments lasted a sufficient length of time.

In the following abstract, from the record of experiments, the notes of secondary importance are omitted, and also the indications of the rule, manometer, etc. The temperature of the feed-water was nearly constantly at 10 deg. C., and the steam pressure oscillated between 3.5 and 4 atmospheres. The experiment proper lasted, without any interruption whatever of the observations (Nos. 5 to 24, inclusive), 6 hours and 30 minutes. 7,000 kilogrammes of coal were burned, the waste heat of which evaporated 11,800 kilogrammes of water, corresponding to 1.7 times their weight.

| No. | Time of feeding. | | Minutes. | Lowering of surface of water in reservoir (inches). | Amount of water fed in cubic feet. | Number of strokes of pump. | Volume of space traversed by plunger (cubic feet). | Useful effect of pump. |
|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | | |
| *1 | 8h.24m. | 8h.36m. | 12 | 12.5 | 9.60 | 1010 | 22.30 | 0.43 |
| 2 | 8h.56m. | 9h. 4m. | 8 | 21.0 | 15.96 | 750 | 16.70 | 0.95 |
| †5 | 9h.41m. | 9h.50m. | 9 | 22.0 | 17.10 | 830 | 18.50 | 0.94 |
| 10 | 11h.10m. | 11h.20m. | 10 | 22.0 | 16.72 | 800 | 17.84 | 0.94 |
| 15 | 12h.39m. | 12h.49m. | 10 | 23.5 | 17.86 | 860 | 19.20 | 0.93 |
| 20 | 1h.59m. | 2h.11m. | 12 | 22.0 | 16.72 | 870 | 19.40 | 0.86 |
| ‡24 | 3h. 9m. | 3h.18m. | 9 | 24.0 | 1[illegible].24 | 900 | 20.07 | 0.91 |
| | Time of observation 6 hours 30 minutes. | | | 428.5 | 340 | 16,680 | 37.26 | 0.91 |

The evaporating capacity of these boilers at 45 kilogrammes per hour per sq. metre, is about twice as large as that of boilers having a fire-box of their own—the latter, as is well known, evaporating only 20 to 25 kilogrammes in the same time to the same surface. Nevertheless the gases pass into the chimneys so hot that the latter have to be lined with fire-brick up to two-thirds of their height, and furthermore, the relative size of the grate to the heating surface is 1:9, while with the common boilers it varies from 1:18 to 1:36.

The 7,000 kilogrammes of coal burned evaporated, as has been said, 11,800 kilogrammes of water—1.7 times their weight. This proportion, it is true, would appear extremely unfavorable, if we did not have to take into consideration that we use here only waste heat, while the real object of the fires is the working of the reheating furnaces. The producing capacity of these furnaces is, moreover, enormously

* The suction pipe let in air, and was made air-tight.
† Commencement of water and coal notations at 9.33 A. M.
‡ End of notation of water and coal consumption at 3.48 P. M.

great in this establishment. The product of 30 rails daily per furnace is hardly reached by any other iron-works in Germany.

Amount of water fed, 340 cubic ft.

Difference between water fed and evaporated in the boilers, 26 cubic ft.

Amount of evaporated water, 366 cubic ft. (11.8 cubic metres), per 6.50 hours.

Amount of evaporated water, 56.3 cubic ft. (1.81 cubic metres), per 1 hour.

Per 1 hour and 1 sq. ft., 0.14 cubic ft. (8 lbs.).

Per 1 hour and 1 sq. metre, 45 kilos.

## RECLAIMING LAND FROM THE SEA.

From "The Mechanics' Magazine."

It has been frequently asserted that the most expensive way of obtaining possession of land is by reclaiming it from the sea. There is not the slightest doubt but that in many instances this assertion has unfortunately proved indisputable. But it is by no means an inevitable sequence that this particular truth should hold good in general, or that those examples in which it has been made manifest might not have demonstrated the contrary had they been differently managed. When failure attends any engineering scheme or project through the ignorance or incompetence of those who are intrusted with the management of its constructive or financial departments, men are but too ready to visit their own faults upon the project itself. They are at once ready to condemn in future all schemes of a nature similar to that which has proved abortive under their own inefficient mal-administration, and thus endeavor to save themselves by avowing the impracticability of that which at one time they regarded as easily achievable. Obviously, they have no other course to pursue, for to believe in the feasibility and success of a project which had died a natural death under their own agency, would be to virtually confess their own inability to contend with the difficulties inseparably attendant upon all works of a somewhat hazardous character. It is perfectly true that failure, even of the most disastrous nature, has attended attempts at reclaiming land from the sea. Equally true is it that success, sometimes of a very remarkable character, has been the result of works of a similar description. Both of these statements will be accepted by our readers as recognized facts, and there is not the slightest necessity on our part to adduce instances to corroborate their accuracy. We shall endeavor in the present article to give some sound practical reasons why failure has attended many of these praiseworthy endeavors to deprive the sea and rivers of territory that they have usurped, and to give to mankind the fertile acres that should of propriety belong to them.

One of the greatest mistakes entertained respecting reclaiming land from the sea is that any land that lies between high and low water mark is fit for reclamation. Considering the great skill and science that are now brought to bear upon all engineering works, it would be perhaps going too far to assert that there is any land so situated, or even in a worse position, that could not be reclaimed. The limits of all such reclamations are bounded, not by engineering, but financial considerations. Land, after all, is only worth so much an acre, and the whole question resolves itself into a simple calculation of capital and interest. As a rule, land to be reclaimed is purchased for a mere song, so that the cost of the works necessary to reclaim it has to be set against the cost of a similar area of land elsewhere. It cannot be denied that the comparatively trifling cost at which a large tract of semi-submerged coast can be obtained is the principal inducement for the investment of capital therein. There are two essential points to be kept in view in purchasing land for intended reclamation. In the first place, the soil must either be of a fertile character or capable of becoming so by the process known as "warping." Secondly, the materials for constructing the embankment must be obtainable on the spot or in the immediate vicinity of the proposed works. There is not the slightest difficulty at arriving at correct information on these points. An analysis will supply the former, and a careful inspection and examination the latter.

Whatever may be the nature of the soil the bulk of the bank must be made with it. If clay, so much the better, if sand, so much the worse; but in any case they must constitute the chief means of embanking the land. Other materials will be also required according to the nature and extent of the work. If parts of the ground be excessively soft and spongy so as not to be able to bear the superincumbent weight of the bank, or if the material be liable to be washed away before it have time to become thoroughly incorporated and consolidated, fascines, or bushes of some kind, must be laid down so as to retain the earth *in situ* until it become firm and consistent. When a very soft piece of foundation is reached, it is idle to think of ever substantially erecting the bank by simply making up its height and slopes as they gradually sink and subside. Something must at once be done towards preventing the gradually slow but certain slipping away of the whole bank. This description of subsidence must not be confounded with that which results from mere settlement and shrinkage of the material, an allowance for which is always made in the estimate for the work. It is a common occurrence, when a portion of a bank is situated on a soft substratum, for the bank to sink, and by its weight to cause the earth to rise in the "delph" or side cutting from which the material has been excavated to form the bank. This is a very annoying circumstance, and sometimes it entails a good deal of trouble and expense before it can be arrested. Considerable discretion must be observed in the employment of bushes or other substances which are specifically lighter than water. If they are not either staked down or loaded with stone, they will be lifted up by the upward pressure of the water, and the bank will be what is termed "blown up."

In order to protect the sea or outer slope of the bank it must be covered with sods or pitched with flat stones. The latter plan can only be adopted in those situations where stone is easily and cheaply procurable. It is, however, absolutely necessary to pitch the outer slope wherever there is any great wash of sea on, as in that case the sods would not form a sufficient protection, although they answer well under ordinary circumstances. They are usually cut wherever they can be got, are about 8 in. or 9 in. deep, and are well beaten on to the slope with a wooden beater or mallet. In some cases, they are let into the slope their full depth, but this is not necessary, except near the toe of the slope. The best protection for a bank against the force or reach of the sea is a piece of foreshore, which should always be left outside it. Unfortunately, it is but too common a practice to diminish this space so much that it becomes nearly useless for the purpose of protecting the bank. Its object is to break the force and roll of the sea, so that by the time it reaches the bank its force is spent, and it scarcely does more than impinge upon the outer slope. It is particularly necessary to leave a good piece of foreshore in front of those portions of the bank which are the most exposed to the prevailing winds and currents. Under no circumstances should it be permitted to be cut away, as it constitutes a far better natural barrier than the best constructed bank can ever prove. The neglect of this precaution has resulted in the failure of a good many banks, and ruined projects that would, if properly managed, have turned out lucrative investments.

With a tolerably good foundation and suitable material, there is very little to apprehend in the construction of a sea bank. It is all pretty plain sailing, and all that is required is extreme vigilance and care on the part of those who are responsible for the construction and maintenance of the work. Constant supervision and inspection is indispensable when an enemy so treacherous as the sea is continually on the alert to destroy the banks which are erected, to restrain his violence and limit his sway. The real and serious difficulty to be overcome in embanking lands from the sea is the stopping of the numerous creeks and inlets with which many coasts abound. Such of these as are of insignificant dimensions are stopped by simply increasing the size of the ordinary bank, but those which assume large proportions demand special treatment. In many instances a regular dam has to be formed, which consumes a large amount of timber, which should be of large scantling. It is a great mistake to be chary of the piling in these situations. If the piles are too slight and not sufficiently braced together, they will be

snapped off short by the force of the water, and the earth washed away in one tide. It is a good plan, when there is danger of the slopes slipping where the bank crosses a creek, to pile the toe, or to construct the dam, with a couple of extra rows of piling, placed somewhere about the level of low-water mark. In any case the use of stone will be found of great service in preventing slipping, provided the foundation is not so soft as to engulph it. If the creeks be once well stopped, and the dams found to remain staunch for a few months after construction, and after being exposed to the storms of winter, the reclamation may be pronounced an engineering success. The erection being accomplished, the maintenance is all that requires to be looked after in future.

## SANITARY WORKS FOR DANTZIC.

From "Engineering."

The town of Dantzic has been rendered memorable in the pages of history on account of the various sieges it has withstood in the time of warfare. It is one of the most strongly fortified positions in the kingdom of Prussia. Here the Government have extensive shipbuilding yards, and factories for the manufacture of the needle gun. The whole bed of the river Vistula flows close past the walls of the town, and forms the principal entrance for shipping from the Baltic, which is about 4 English miles, by the channel of the river, distant from the town. The place is now chiefly celebrated for its exports of corn and timber, and within the last 5 years much attention has been given to the sanitary condition of the place. In 1865, Mr. Wiebe, C. E., Government engineer of Berlin, prepared a project for the authorities of the town for effecting its sewerage. Nothing, however, was done with respect to this project, as no engineering work of like character has ever been carried out in the kingdom of Prussia, and as the engineer who advised this scheme of sewerage had had no practical experience with regard to the execution of such works. In 1868 Messrs. J. & A. Aird were consulted as to the feasibility of carrying out the plan. In 1869 they recommended that an English engineer should be called in to advise and report upon the scheme proposed by Mr. Wiebe. Mr. Baldwin Latham, C. E., of 7 Westminster Chambers, S. W., was the engineer selected, and from his report, which was presented at the time of his visit and inspection, we quote the following observations: "It has been my privilege to examine, report upon, and carry out the sanitary works in a large number of English towns, but in the whole course of my experience I have never before been called upon to visit and inspect a town in which such an utter disregard is paid to sanitary measures as I find in Dantzic; and I am still more surprised that such an unsanitary state of things could be allowed to exist for one moment longer than necessary in any civilized community. Pure air is absolutely necessary if life and health are to be maintained, and in Dantzic, where a great number of persons are congregated in a comparatively limited area, the retention of such offensive matter that everywhere meets the eye (if only retained for a limited period) is effectually vitiating the atmosphere which the inhabitants are compelled to breathe; and the result is that your death-rate is greatly above the average of any German town." The rate of mortality in Dantzic, in 1869, was 37 per 1,000, and the birth-rate was very much lower than the death-rate. Mr. Latham points out that "Dantzic must, without doubt, sooner or later, decline, unless the population is maintained by the influx of people from other parts of the Prussian Empire." The fearful death-rate of Dantzic, judged merely in a political point of view, he shows, "cannot be without its warning, as the town is unable to maintain the number of its population without drawing on the resources of the empire. The unsanitary condition is immolating its victims faster than they are being supplied in the ordinary course of nature; therefore it is not very difficult to see what must be the ultimate result of this state of things if allowed to proceed. In a financial point of view there is nothing so expensive as disease and death. The power of physical

ability forms the basis of value of all labor, and yearly Dantzic, with its frightful rate of mortality, must be called to sustain the burden arising from the physical inability of a portion of its population to sustain life by reason of the effects of disease, or the removal by death from preventable disease of the bread-earner of the family." To bring the sanitary state closer home, Mr. Latham states that "the great rate of mortality is due to the deaths of the younger portion of the population. This in itself at once testifies the necessity for sanitary reform, because it is seen that those of tender years, who live more closely in contact with the causes that are so prejudical to health and life—and who naturally, from the fact of their age, are less capable of withstanding the inroads of disease—suffer the most. The excessive mortality among the young may be taken as a sure sign of the want of proper sanitary arrangements, by which arrangements the predisposing cause of disease may be removed. It appears that the present average duration of life in Dantzic is but 23 years. This is an extremely low average, and at once speaks to you in the strongest terms as to the absolute necessity of looking at the matter in a philanthropic point of view, of doing something whereby the ride of disease and death may be staid. I have not the slightest doubt, in my own mind, that if proper sanitary measures are adopted in Dantzic the average duration of life will be increased at least one-third, and that the death-rate will be reduced in proportion." There are at the present time about 70,000 inhabitants within the fortifications, and about 20,000 in the suburbs and adjacent thereto. It is pointed out, in the report already referred to, that taking the population of the two places, and by the reduction of the rate of mortality, at least 1,200 lives may annually be saved by the prosecution of sanitary works.

Of the scheme proposed by Mr. Wiebe, Mr. Latham speaks in very high terms, but suggesting, however, such modifications as experience in similar works has found to be necessary in order to render a system of sewage efficient. Shortly after the consideration of the report referred to by the town magistrates, the works of the contract were given to Messrs. J. & A. Aird, of Berlin, to carry out the project, embracing such alterations and additions as were suggested by Mr. Latham. A concession of the sewage of the town and about 2,000 English acres of land have been granted to Messrs. Aird for a term of 30 years. It is pointed out in the report that a scheme for the utilization of sewage was absolutely requisite in a town situated like Dantzic. The Baltic being a tideless sea, the river flowing from the town of Dantzic being extremely sluggish, and much used by the shipping, and generally for mercantile purposes, the discharge of large volumes of sewage would be attended with very baneful effects; therefore it was absolutely necessary in a town so situated that the sewage should be conveyed direct to the sea or into the river channels in as pure a state as possible. Owing to the low level at which many portions of the district lie, in order to maintain a system of sewage, it was necessary that pumping should be resorted to for the purpose of effecting the drainage of the town, so that it became a question of but slightly increasing the power of the engines in order to lift the sewage on to the lands in the neighborhood. Close to the town are many thousands of acres of sterile land of little or no value; the application of the sewage to this land, therefore, would, of itself, confer a great benefit upon the town by converting sterile wastes in its immediate vicinity into the most fertile land. The town, within the fortifications, may be considered to be divided into three portions, all of which are surrounded by water, either by the fortifications or by branches of the rivers running through the town. The central portion, having water on both sides, is entirely occupied by granaries. A small unoccupied portion in the central part, called the Kampé, which is an island of itself, is the point where the whole of the sewers in the town and suburbs are made to converge. The sewage is conveyed to the pumping station by siphons laid under the navigable channels of the district, so that for navigation 18 ft. of water have to be maintained. The principal sewers are of brick, and have a fall to the point of outfall of 1 in 2,400. Subsidiary sewers are constructed of earthenware pipes. The principle kept in mind is to lay them in perfectly straight lines, with a manhole or ventilator at each vertical or lateral change of direction.

Every manhole can be used as a flushing station. The system of sewerage has also been adapted to the efficient ventilation of the sewers. The system being so broken up, the gases will not traverse from the lowest to the highest districts, but the ventilation of each district will be secured locally. The ventilators used are "Latham's patent combined manhole ventilator and lamphole." The sewage on arriving at the pumping station is passed through two of Mr. Latham's patent sewage extractors, similar to those in use at Croydon. These extractors remove the sand and other solid matter which it is not intended to apply directly to the land. The liquid sewage is then pumped through a 22 in. main, about 2 miles in length, to the proposed area for irrigation. This area until recently has been covered with pine forests, which is being cleared as fast as possible, in order to fit the land for the reception of the sewage. From experiments that have already been made with regard to the application of sewage to land, it has been shown that crops equal to those produced in this country are capable of being grown there. The highest chemical authorities in the United Kingdom of Germany pronounce the irrigation system as being not only the best, but the only possible system whereby sewage may be properly utilized, and we trust that Messrs. Aird, who have the concession of these works, and who are taking the lead in this matter in Germany, will meet with the success of which they are in every sense deserving.

## ARRANGEMENT AND MAINTENANCE OF BATTERIES.

By GEORGE B. PRESCOTT.

From "The Journal of the Telegraph."

Among the most important matters pertaining to the management of our lines, not only in a pecuniary point of view, but in their relation to the practical working of the wires, are the construction, maintenance and distribution of the batteries which supply the main circuits. The pecuniary importance of the subject is apparent from the fact that more than $100,000 are annually expended by the Western Union Telegraph Company in this department alone, the cost averaging nearly $1 per mile of wire. As there is, however, a material difference in the annual expenditure at the various stations where main batteries are maintained for supplying the same length of circuit, it shows that there is a considerable margin for improvement in many sections of the line. As all the employees should aim at securing the best results in every department, it is very important that the principles which govern the propagation of the electric current should be so well known that every one connected with the service may be able to attain the maximum of efficiency and economy in the management of his batteries. The design of this article is to furnish such information as is apparently required to secure a uniform system of batteries throughout the Western Union line.

The cost of maintenance of a galvanic battery is proportional to the amount of zinc and acids consumed.

The consumption of zinc and acid in a properly constructed battery of any given number of cells, is proportional to the number of wires (of equal resistances) supplied from it, or to the amount of work done.

The consumption of zinc and acids in working a given number of wires of a certain length, size and quality, is proportional to the number of cells in the battery.

The quantity of electricity required to operate a telegraph wire is an amount sufficient to work the relays in the circuit.

The quantity of electricity which exists in the form of a current upon a given length, size and quality of wire, is proportional to the number of cells in the battery; for, while the quantity of electricity produced by a battery is proportional to the amount of zinc decomposed in each cell, and is no greater in a battery of 100 cells than in a single element, the electro-motive force which is required to overcome the resistance of the conductors, or to force the quantity generated by the single cell through the wire, increases with every additional cell.

The quantity of electricity existing in

the form of a current upon a telegraph wire from a given number of battery cells, is inversely proportional to the resistance of the wire, relays and battery.

To summarize :

The electro-motive force being constant, the quantity of electricity which flows through any circuit is invariably proportional to the resistance.

The resistance being constant, the quantity of electricity which flows through any circuit is directly proportional to the electro-motive force.

It is evident from the above considerations that the number of cells employed in a battery for working a telegraph wire should be strictly proportional to the resistance of the wire and relays. If a battery of a certain number of cells is employed to work several wires, the resistances of all the circuits should be approximately the same ; for if a wire 100 miles long is attached to a battery which supplies another wire of twice the length, the shorter wire will have twice the quantity of current that the longer wire receives. If, therefore, the electro-motive force of the battery is sufficient to work the longer wire, it is twice as great as the shorter wire requires, and the surplus strength is wasted. In estimating the length of a wire, of course the resistances of the relays must be included, and the size and condition of the wire, or its conductivity, properly considered.

Let us suppose that a battery of 50 Grove's cells supplies a current to the following wires, and, applying the foregoing principles, ascertain what the strength of current will be upon each wire :

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| No. | 1 | Wire, | 150 | miles long, | with | 38 | relays. |
| " | 2 | " | 150 | " | " | 34 | " |
| " | 3 | " | 150 | " | " | 29 | " |
| " | 4 | " | 150 | " | " | 24 | " |
| " | 5 | " | 150 | " | " | 18 | " |
| " | 6 | " | 85 | " | " | 14 | " |
| " | 7 | " | 170 | " | " | 7 | " |
| " | 8 | " | 100 | " | " | 13 | " |
| " | 9 | " | 100 | " | " | 5 | " |
| " | 10 | " | 100 | " | " | 3 | " |
| " | 11 | " | 150 | " | " | 2 | " |
| " | 12 | " | 50 | " | " | 2 | " |

Call the electro-motive force E.
" resistance of the line L.
" " " relays R.
" " " battery r.
" quantity of the current Q.

Then $Q=\frac{E}{L+R+r}$

Assuming that the electro-motive force of the battery is 50,000 units ; the resistances of the relays 200 ohms each ; the resistance of the wire 20 ohms per mile ; and the resistance of the battery 50 ohms, we have the following as the quantity of electricity, or strength of current upon the above wires. E=50,000.

| | | | | |
|---|---|---|---|---|
| No. | 1 | L=3000; R=7600; r=50. | Strength of current, | 4.69 |
| No. | 2 | L=3000; R=6800; r=50. | " " | 5.07 |
| No. | 3 | L=3000; R=5800; r=50. | " " | 5.64 |
| No. | 4 | L=3000; R=4800; r=50. | " " | 6.57 |
| No. | 5 | L=3000; R=3600; r=50. | " " | 7.51 |
| No. | 6 | L=1700; R=2800; r=50. | " " | 10.9 |
| No. | 7 | L=3400; R=1400; r=50. | " " | 10.3 |
| No. | 8 | L=2000; R=2600; r=50. | " " | 10.75 |
| No. | 9 | L=2000; R=1000; r=50. | " " | 16.37 |
| No. | 10 | L=2000; R= 600; r=50. | " " | 18.87 |
| No. | 11 | L=3000; R= 400; r=50. | " " | 14.49 |
| No. | 12 | L=1000; R= 400; r=50. | " " | 38.49 |

Thus it will be seen that the strength of the current on No. 12 is more than 8 times as much from the same battery as upon No. 1, and the expense for material consumed is increased in the same proportion. The cost for zinc and acids for working 12 wires of the various resistances above-mentioned, from one battery, would be equal to that for supplying 22 wires of resistances similar to the greatest.

Aside from the fact that the expense of maintaining the batteries is unnecessarily increased by attaching short wires to batteries arranged for working long circuits, there arises more or less difficulty in operating the wires, owing to the variations of the current, which would be materially lessened by connecting only wires of similar resistances to the same battery.

By our system of working with closed circuits, we depend for our signals upon the difference in the strength of current at the receiving station, occasioned by the opening and closing of the circuit at the sending station. In dry weather, this difference may be nearly 100 per cent., and in wet weather, perhaps less than 5, so that during a heavy rain storm, when the escape is very great, the variations in the strength of current upon a receiving wire, occasioned by simultaneously opening and closing half a dozen keys at the receiving station, upon other wires attached to the same battery, would be greater than the percentage of difference caused by opening and closing the circuit at the sending station.

As the consumption of battery materials is proportional, other things being equal, to the number of wires operated, the cost of supplying the wires with an electric

current is theoretically the same, whether you employ one battery for working 20 wires, or a separate battery for each wire; but, practically, there would be some saving in the expense of taking care of one battery instead of 20, as well as in the loss from local action; so that if you work a number of wires of equal resistances from one Grove battery, the expense would be somewhat less than if a separate battery were employed for each wire. Much better results in working our lines, however, especially in wet weather, would be secured by using a separate battery for each wire, but as this would necessitate the occupation of considerable additional room at most large stations, which could not readily be obtained, it is scarcely practicable to inaugurate the change at once. The next best thing to having a separate battery for every wire, is to have as many batteries, in proportion to the number of wires, as can conveniently be obtained.

There is a limit to the number of wires which can be properly worked out of one battery, even in the most favorable weather, and in wet weather this limit is reached much sooner than is generally imagined.

The maximum strength of current is obtained when the resistance of the battery equals that of the closing arc. Now, as the resistance of conductors is inversely as their conducting powers, multiplying the number of conductors divides the resistance.

Suppose, for example, 30 wires of No. 8 gauge, each 230 miles in length, were attached at their termini to two Grove batteries of 50 cells each. The resistance of the two batteries would be 100 ohms, and the resistance of each wire 3,220 ohms; but as multiplying the number of wires divides their resistance, the resistance of the 30 wires would be but 107 ohms, or only 7 ohms more than that of the battery. This, it will be observed, is in dry weather, when there is no escape; but if, during a heavy rain storm, the amount of current that escapes to the ground be six times as much as that which traverses the wires, then the total resistance of the closing arc would be but 18 ohms. Thus, in rainy weather, the resistance of the wires would be so greatly reduced as practically to put the battery on short circuit, and it would run down very rapidly in consequence.



Where a great number of wires are worked from one battery, or where the wires are poorly insulated, a slight improvement is made by placing two batteries side by side and connecting the poles of the same name together. This is equivalent to doubling the size of the zincs, and reduces the resistance of the battery one half. In the case above mentioned, if the batteries had been arranged in this manner, the resistance of the batteries would have been but 50 ohms, and therefore the proportion of resistance of wire to battery would have been doubled.

This mode of arranging the batteries is sometimes erroneously called doubling the quantity. As the quantity of current generated by a battery is proportional to the amount of zinc dissolved in each cell, and this decomposition is directly proportional to the electro-motive force of the battery, and inversely by the resistance of the circuit, the quantity is only increased by enlarging the size of the zincs in proportion to the reduction of the resistance.

In a long telegraphic circuit, the increase in the strength of the current in the wire by reducing the resistance of the battery is barely appreciable, as will readily be seen by the following examples:

Take a battery of 100 Grove cells, arranged in the usual manner, and attached to a No. 8 iron wire 230 miles in length. Calling the electro-motive force 10,000 units, the resistance of the wire 3,220 ohms, and the resistance of the battery 100 ohms, the quantity of current on the wire would be $\frac{10,000}{3220+100}=3.01$.

Now take two batteries of 100 cells each, and place them side by side with the poles of like name connected together. The electro-motive force will be the same as in the other case, but the resistance will be halved, and therefore the strength of current on the wire will be $\frac{10,000}{3220+50}=3.05$.

If the 100 cells were divided into two series of 50 cells each, and these were placed side by side with the poles of similar name connected together, the electro-motive force would be reduced 50 per cent., and the resistance 75 per cent., and therefore the strength of current on the wire would be $\frac{5,000}{3220+25}=1.54$.

Thus, while doubling the size of the battery, by placing two series of 100 cells each side by side, only increases the quantity of electricity on the wire $\frac{1}{100}$ of 1 per cent., the division of the bat-

tery into two series of 50 cells each, arranged side by side, reduces the quantity of current on the wire 48 per cent. To obtain the same strength of current upon an ordinary telegraph wire by doubling the size of the batteries in this manner requires, therefore, twice as many cells as in the ordinary arrangement. Of course a battery of this kind would last twice as long—when supplying an equal number of conductors—as one of the ordinary construction; but as it costs twice as much to make it, and double the fluid to feed it, there is no economy in its use.

If the proposition were: What arrangement of the cells will best supply the largest number of wires from one battery with the least difficulty? the answer would be, the latter; since, as with the electromotive force the resistance is halved, the number of wires may be doubled; but as twice as many cells are needed to produce this result, there is no economy in the arrangement, because the additional series of cells could just as well be used as another single battery, and the wires divided between the two.

As the number of cells in the battery should always be proportional to the resistance of the circuit worked, it will be found useful to have a fixed standard to refer to as a guide in arranging the batteries for the lines. From a somewhat extended examination of the battery power actually employed upon our wires in various sections of the country, I find that one Grove cell is the maximum amount required for working through 120 ohms circuit resistance. Such stations as may not have the means of accurately measuring the resistances of their wires and relays may make an approximately correct estimate in ohms by multiplying the number of relays by 200, the number of miles of No. 8 iron wire by 14, and the number of miles of No. 9 iron wire by 20. Of course, this mode of arriving at the comparative resistances of the circuits is very rough and imperfect, and is only suggested for such exceptional cases as may exist where no tests of the wires and relays have been made with a galvanometer. There ought not to be a mile of wire in operation, or a relay in use, the resistance of which is not accurately known. Of course, the conductivity of a wire is materially increased by soldering the joints, and much less battery power is required to work the same length and size of wire where the joints are soldered than where they are not. In the absence of accurate measurement, this matter should be taken into account in estimating the number of cells required to work a given length of wire.

A considerable diversity of opinion exists in regard to the comparative economy of employing the different kinds of batteries for working the main circuits. Without discussing the various theories advanced by the advocates of each particular combination, I would suggest that as the consumption of zinc and acids is proportional, in every case, to the amount of work done, there would not appear to be any substantial reason for the great differences in the cost of maintenance of one kind of battery over another, or of the different varieties of the same species of battery, which are claimed; and the actual expenditures for this branch of the service seem, upon examination, to render this question rather one of economical use of the variety employed than of any peculiar merit in the kind selected.

The Western Union Telegraph Company employs the Grove, Carbon, and, to some extent, the Daniell batteries, to work its main circuits, the three kinds being used in the following proportions: Grove, 53 per cent.; Carbon, 43 per cent.; Daniell, 4 per cent.

A careful examination of the actual expense for battery power at each office where main batteries are located shows that the annual cost per mile of wire averages precisely the same for both Grove and Carbon, and approximately the same for the Daniell. This result is the more remarkable since the expense per mile of wire is as various as the number of stations, no two offices showing the same cost for either of the batteries. As would naturally be anticipated, the cost per mile of wire is greatest where the number of cells employed for each battery is out of proportion to the length of circuit to be worked, or where a large number of wires of greatly varying resistances are attached to the same battery. This result is so general that an examination of the expenses at any office furnishes an almost absolute index of the disposition of the batteries, or amount of force employed at that place.

Great care should be taken to keep the batteries in good order and prevent any local action in them. The floors and tables in the battery room should be kept scrupulously clean and dry, and each cell thoroughly insulated, so as to prevent the least leakage or escape of the current. Particular attention should be given to the ground wires attached to the batteries, as the strength of current upon the wires depends greatly upon the degree of conductivity of the ground connections. It is preferable to employ a separate ground wire for each battery, and they should, wherever possible, be attached to metallic water pipes, or to the main gas pipes. In all cases the joints of the wires, and the connections with gas or water pipes, should be securely soldered. Whenever it is impracticable to connect the ground wires to water or gas pipes, they should be attached to large plates of copper buried in the earth to a sufficient depth to insure their being at all times surrounded by moisture. I have frequently doubled the strength of current upon a wire by simply improving the ground connection.

Batteries which are only used during the day should be invariably taken down at night, and the nitric acid poured into glass vessels and tightly corked, so as to prevent waste from evaporation. By adding a little fresh nitric acid each morning the strength of the batteries may be constantly maintained. Much unnecessary expense is incurred by throwing away only partially used acid. The sulphuric solution employed in the outer cells should never be stronger than one part acid to twenty of water, but it is well to change this solution often, for when it becomes saturated with nitrate of zinc, the action of the battery is very much weakened. The saturation of the solution manifests itself by the formation of crystals upon the zinc cylinders.

The number of wires attached to one battery should never exceed five; for, although a much greater number can be worked from a single series in dry weather, without appreciable inconvenience, the unavoidable difficulties due to imperfect insulation in rainy weather are unnecessarily supplemented by those arising from over-worked batteries. As no possible gain can be secured by thus overloading them, but, on the contrary, much loss is almost certain to result from this source, there can assuredly be no good reason for continuing the practice.

The result of the foregoing considerations may be briefly stated thus. To secure the best working currents at the least expense:

The batteries should always be kept in the best condition for work, each cell being thoroughly insulated, and the floors and tables in the battery room kept scrupulously clean and dry, so as to prevent the least leakage or escape of the current.

The number of cells in the batteries should be strictly proportional to the resistances of the circuits which they are to supply.

If more than one wire is supplied from the same battery, the resistances of all the wires attached to it should be approximately the same.

Five wires is the greatest number that should, under any circumstances, be supplied from one battery.

The number of cells in all the batteries employed upon one circuit, should not exceed one cell for every 120 ohms resistance.

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New Colorimeter.—M. Duboscq, of France, has invented a new instrument for measuring the differences of tint in solutions. Two glass cylindrical vessels, containing the liquids to be tested, are placed side by side on a shelf; in each is a smaller tube closed at the lower extremity by a glass dish, which may be raised or lowered by means of a pinion having fastened to it a vernier moving over a graduated scale, so as to measure the distance between the bottom of the vessel and the lower disk of the movable tube. Luminous rays are transmitted through the bottom of the cylinder, by means of a mirror and by two Fresnel rhombs above the cylinder, in such a manner that each will illuminate half of the field with a semi-disk of yellow light more or less intense. These colors are observed with a terrestrial eye-piece formed of four glasses, by which the field may be illuminated with perfect uniformity. The colors are proportional to the height of the columns if the liquid contain the same proportion of caramel, or in proportion to the richness of the liquid in caramel if the two columns have the same height.

## THE CONSTRUCTION OF PIER 4 OF THE KANSAS CITY BRIDGE.*

Work was begun upon this foundation on the 2d of September, 1867. The water was then 20 ft. deep, and piles could be driven only with great difficulty; no less than 6 were pulled out by the current. It was at first designed to scour out a deep pit by the use of wing dams, but before the plan could be carried into effect, the current, which is more variable at the site of the pier than at any other point on the line of the bridge, slackened to almost nothing, making wing dams wholly impracticable. A caisson of rectangular form was then built in position, 67 ft. long, 30 ft. wide, and 22 ft. high. It was put together without spikes or pins, the planks being secured between cleets on the sides of the posts, and the whole caisson bound together by iron rods passing from the bottom of the sill to the top of the plate. It was proposed to sink this caisson about 20 ft., drive a pile foundation within it, cut off the piles at the level of the base of the caisson, build the pier on a suspended grillage, and lower it upon the piles. Then upon unscrewing the nuts and withdrawing the long rods, the caisson would fall in pieces and a riprap protection could be thrown close around the pier.

The slackening of the current was accompanied by a rapid deposit of sand, and before the caisson could be completed there remained but 18 in. of water at the site of the pier; in 8 days only, from the 18th to the 26th of September, a deposit of 12 ft. deep was formed. On the 26th of October the caisson was done, when it was tripped to the bottom by striking the braces which supported it. The change in the level of the river bed made a corresponding increase in the distance which the caisson must be sunk by excavation. This excavation was shortly begun by means of the steam siphon and hand dredge, and continued until the tools were transferred to Pier No. 3, the caisson having then been sunk about 9 ft. During the winter an inner wall was completed within it, and the intermediate space, about 5 ft. wide, was filled with stone and sand. An ice breaker, formed of an inclined sycamore log and a fender of planked piles, was built above the pier site. In February a large dredge, with a steam-engine to drive it, was mounted upon the caisson; it was set in motion on the 13th of that month, and lowered the caisson a few feet. The rising water on the 8th of March produced a moderate scour, which aided the sinking; on the 17th the scour increased very rapidly on the south side, and the caisson began to tilt over; the next morning the water was found to be 22 ft. deep there, while no corresponding wash had occurred on the north side. Under the combination of this undermining of the southern cutting edge, and the pressure of the sand against the north side, the caisson settled over till only the north-east corner remained above water. By hard work through the morning and dinner hour the machinery was removed and placed on boats. By 2 P. M. the whole caisson had disappeared; the weight of the sand and stone with which the walls were loaded, together with the external sand pressure, proved too great for so loose a structure; it broke in settling, and became a total wreck; a few of the timbers cleared themselves, and floated down stream, but the greater part of the wreck, being of green oak and covered with sand and stone, remained at the bottom of the river.

The loss of this caisson put an end to the work which had thus far been done on this foundation, making it necessary to start entirely anew. Moreover, the circumstances attending the wreck showed the exposure of this site to be so great that it was thought unwise to adhere to the plan of a pile foundation. The situation of this pier, between the edge of the sand bar and the low-water channel, exposes it to more frequent washes and deposits than have been observed elsewhere, while it is also liable to be subjected to the thrust of a heavy bank of sand on the north side, with no counterbalancing pressure on the south side, a danger from which the other piers are free. For these reasons it was determined to treat this as a channel foundation in preparing the new plan, and to extend the full-sized pier down to the

* The Kansas City Bridge. By O. Chanute, C. E., and George Morton, Assistant Engineer. New York: D. Van Nostrand, 1870. For some account of the superstructure see September No. of this Magazine.

rock. To avoid the difficulties of passing through the old wreck, which would have made it necessary to resort to the use of compressed air, and which it was feared would have delared the completion of the bridge through another season, the location of the pier was shifted 50 ft. to the south, reversing the distances between it and the two adjoining piers, and placing the long span, 250 ft., between piers Nos. 4 and 5.

At the location now selected, the rock was assumed to be at an elevation of 55 ft. and to be overlaid, during the best working season, with about 40 ft. of sand, which would probably make it necessary to do some portions of the work in 50 ft. of water. Borings taken indicated rock at 58 or 59, but were not wholly satisfactory. The methods by which the other deep sand foundations had been put in, though successful, had been very slow, and were likely to prove impracticable when the depth of sand became doubled, while, even if a bottomless caisson could be sunk to the depth now required, the season between two floods would be found too short to complete the work by putting in a subaqueous foundation of beton, 30 or 40 ft. deep. For these reasons a plan was prepared resembling in many respects the process which was first introduced in founding the piers of the bridge over the Rhine at Kehl, and which has since been very generally employed by European engineers; in all previous works, however, the excavation has been made by laborers working in a pneumatic chamber—machinery, if used at all, serving only to remove the material which had first been handled by the men; but in these plans the machinery was so arranged as to be self-feeding, and the excavation was carried on without the use of compressed air. A pier of masonry was to be built in position above water, and sunk to the rock, by excavating the underlying sand with dredges working through wells left in the masonry, guiding the mass in its descent by suspension screws, and keeping the top of the masonry above the surface of the water by building on the successive courses as the sinking continued.

A caisson was designed which should serve as a support for the pier in its descent, and which, while of such form as should furnish the best facilities for excavation below, should bear, without yielding, the weight of 40 ft. of masonry above, and the pressure of sand and water against its sides. The construction of this caisson was begun on the 25th of June, 1868, on the north bank of the river, 400 yards below the bridge line. It measured 70 ft. from nose to nose, 20 ft. 6 in. in width, and 11 ft. in height. The sides were built of square timber; the main sills were of oak, 15 in. square, of one piece from shoulder to shoulder; the 7 succeeding courses were pine, 8 in. by 12, placed on edge, and the 2 upper timbers were oak, 12 in. square; a triangular piece of oak was placed below the main sill. The successive courses were pinned together with 2 in. turned pins of oak, and bolted to uprights placed in the angles, and at intermediate distances along the sides; the outside was covered with 2 courses of 3 in. oak plank, dressed in a planer to an even thickness, the planks of the inner course making an angle of 45° with the horizontal timbers, and those of the outer course being put on vertically, with the smooth side outwards. It was at first proposed to cover the whole with thin sheet-iron to reduce the friction of the sand upon the sides; but experiments made to ascertain the coefficients of friction of sand against various substances, showed so slight a difference between iron and dressed oak, that the covering was not put on. Within this outer wall was placed a second wall inclined inwards; it was framed of oak timbers, 10 in. square, which rested upon the main sills and bore against a pier of 12 in. timbers, placed parallel with the upper timbers of the sides; this inclined wall was carried round the triangular ends, the framing being modified to accommodate the angles. Three braces, 15 in. square, were placed immediately above the main sills, extending across the caisson and bearing against the upright timbers; these served also as the basis of 3 V-shaped cross-walls, each formed of 2 equally inclined rows of oak sticks 8 in. square, fitted into 15 in. timbers above; the lower angles of the cross-walls were formed by triangular pieces of oak, along the lower edges of which ran 3 iron rods, 2 in. in diameter, which passed through the main sills and tied the whole caisson together; each cross-wall was further strengthened by a truss built into the middle of it. The timbers of the inclined

walls were thoroughly stayed by iron bolts binding them to the outer walls, and the cross-walls were strengthened by rods connecting their upper timbers ; the interior framing of the starlings was secured by hanging it from a truss placed above, and the top of the caisson was tied across by 2 in. rods placed at the shoulders, and by dovetailing the 15 in. cross timbers into the sides. The whole interior frame was sheathed with 2 in. oak plank, but the spaces between the double walls were left entirely open above. The cutting edges of both main and cross-walls were protected by a covering of $\frac{3}{16}$ in. boiler plate, the plates being bent and cut to fit the angles and corners, riveted together and fastened on with wrought-iron spikes.

The combination of the V-shaped cross-walls, with the inclined walls of the sides, divided the interior of the caisson into 4 bell-shaped chambers, the two central ones being nearly square, and those at the ends of pentagonal form, each having a rectangular opening above 5 ft. 4 in. by $9\frac{1}{2}$ ft.. This form is one at once well suited to sustain the weight of superposed masonry, and especially adapted to facilitate excavation. The caisson is thoroughly braced by the interior walls, and not encumbered with exposed brace timbers ; the walls and edges are of such form as to act as wedges, which, under the weight of masonry, and by pressure above, feed the sand towards the centres of the chambers where the dredges work ; while, as the cross-walls were placed 30 in. above the outer edge, a diver could have free access from chamber to chamber, should this be found necessary.

Twenty-four suspension rods, each 24 ft. long and $2\frac{1}{2}$ in. in diameter, with the upper end formed into an eye, were built into the walls. They were arranged in pairs, and passed through every square timber in the outer walls, taking hold with nut and washer on the under side of the main sills, the nut fitting into a square recess cut in the triangular stick below. Eighty $1\frac{1}{4}$ in. gas pipes were also placed in the caisson, arranged along the sides and cross-walls, and terminating in cast-iron nozzles immediately above the iron plating ; they were intended for water-jet pipes, but the sand fed itself so well to the dredges that none of them except those in the angles were ever used. The whole planking was thoroughly caulked, and the interior coated with roofing pitch. A frame, provided with bolt holes, was carefully fitted into the rectangular opening above each chamber, and an accurate pattern taken, from which a cover could be made to fit this frame ; so that in case extraordinary obstructions were encountered, the dredge could be withdrawn, the cover or trap placed in the frame, and bolted tight by a diver, converting the chamber into an air-tight caisson, when the obstructions could be removed by working in compressed air.

Under other circumstances it would have been preferred to build this caisson entirely of iron ; but the distance from adequate iron works, and the absence of boiler-makers and competent workmen, were unfavorable to doing so ; on the other hand, timber could be obtained without difficulty, and there was no scarcity of carpenters ; so that it was thought best to build of wood, which involved much complicated detail and difficult framing.

The caisson was provided with a false bottom placed below the cutting edge, over which it fitted like the cover of a paper box, braced against the cross-walls, and secured by iron rods. Five launching ways were placed below, which were carried out into deep water on piles, and the completed caisson was lowered by jack-screws upon 5 flattened timbers, fitted with guides, and arranged to slide on the ways.

The first work done in the river was to drive a compact clump of anchor piles, 100 ft. above the proposed pier ; these were driven and protected by riprap before the June flood ; but it was thought unwise to drive the false-work piles at that time, because, even if they should remain undisturbed by scour, they would inevitably collect a large amount of drift, which might form an obstacle in the way of sinking the pier scarcely less serious than the wreck of the old caisson. On the 9th of August this danger was passed, and the driving of the false-work piles was begun. They were 60 in number, of which 48, two at each end, were intended to carry the weight taken by the suspension screws, the other 12 serving only as supports for the false-works. The two central piles on the lower end were not driven till after the caisson had been floated into place. The disturbances

of the river made the driving of these piles less exact than it should have been, but the irregularities were not too great to be taken out in the platform above; they were generally driven from 25 to 30 ft. into the sand, some of them even reaching the rock.

The piles were cut off as soon as driven at an elevation of 106.5, a platform was built upon them, and the trusses were raised which were to carry the suspension screws. These trusses were 7 in number, and proportioned to carry a safe load of 1,000 tons. Each end truss carried 2 suspension screws, and each of the intermediate trusses 4, the screws being in pairs, and placed to correspond with the rods in the caisson. These screws were 24 ft. long, ten of them 3 in. in diameter, and the other 14, which had been used in lowering the masonry of the Quincy Railroad bridge, 2½ in. Ten additional screws of the same size as the latter were kept in reserve.

On the morning of the 21st of October the caisson was successfully launched and towed to the false-works. Two or three weeks previously a large flat-boat loaded with sand, in attempting to shoot the works, had struck against one of the upper piles and sunk; the wreck had caused a sand deposit at the pier site, so that, though there was plenty of water to float the caisson, which drew only 3½ ft., it could not be brought under the trusses without removing the suspension rods; they were, accordingly, unscrewed, taken out, and the caisson brought into position, when they were replaced and easily screwed into the nuts, which were held by the square recesses cut in the triangular timber below the sill. This was accomplished in a day, but the want of deep water proved a more serious obstacle in the way of removing the false bottom. It had first been proposed to sink the bottom by throwing in sand, water being already admitted above it, make fast to it with the steamboat, and pull it out below; the depth of water proving insufficient for this, it had to be broken in pieces, and taken out in small parts, an operation which involved nearly two weeks' delay, and which, it was feared, would cause trouble by leaving unremoved fragments; an apprehension which fortunately proved groundless. A week later a sand bar, which had already been observed forming in front of the launching ways, had so much increased that it would have been impossible to launch the caisson, so that a tedious portage by land was narrowly escaped.

On the 11th of November, the work was begun of filling the spaces between the double walls of the caisson with beton, while the false-works were completed, and the machinery mounted as fast as could well be done. The false-works were built with 3 floors; the lower one, intended for the use of carpenters and masons, was placed at at elevation of 108.7, and made a continuous platform extending on all sides of the caisson; it was generally left open on all sides, but a small house was built at the south-east corner, in which a 25 horse-power engine and a donkey pump were placed; a room was also enclosed in the middle of the south side for the use of the divers, where the air-pump and submarine apparatus was kept. At the south-west corner a staircase led to the second floor, which was placed on a level with the lower chords of the trusses. This floor extended over the caisson, having 4 holes in it through which the dredges worked; it was completely housed in, was provided with work benches, warmed by stoves, and contained the lamp-room and superintendent's office. At either end a staircase led to the third floor, a narrow platform, resting upon the upper chords of the trusses, where stood the 4 hand-crabs used in handling the dredges.

The excavating machinery consisted of 4 large dredges of the endless chain pattern. They were mounted with vertical telescopic frames of wood, the lower tumbler being attached to a single frame, inclosed by a double frame which carried the upper tumblers; the boxes of the upper tumbler were set on adjustable blocks. By this arrangement the dredges could be lengthened to suit the depth at which they were operating, the length being varied from 51 to 85 ft.; this was done by removing the bolts which united the 2 frames, putting in an additional length of dredge chain, with the proper number of buckets, and raising the outer frame till the length of the added chain was taken up; the bolts were then replaced and such slack as might remain in the chain taken out with the adjusting screws. The entire frames were raised

and lowered independently of this change in their length, by chains which passed through sheaves on the sides of the double frame, and were worked by the crabs on the upper floor. Two of these dredges had originally been used on the Quincy bridge and were now rebuilt to adapt them to this work; a third was similar, and had been made from the same patterns, though designed in the first instance for use at Kansas City, on the old No. 4 foundation. These 3 dredges had square tumblers of cast-iron; the links of the chains measured 22 in. between centres, and the buckets were bolted on every fourth link through holes drilled for the purpose. The other dredge was constructed especially for use on this pier; the tumblers were of hexagonal form, made of oak and bound with wrought-iron; the chain links were only 12 in. long between centres formed with upset ends; the buckets, whose form was novel, were placed on every sixth link and held by the same pins by which the links were coupled, an arrangement relieving the links of any transverse strain, the merit of which was proved by the fact that the chain of this dredge never broke; the hexagonal tumbler was also found to give a steadier motion than the square ones.*

A single line of shafting mounted on hangers attached to the trusses, and driven by the engine on the floor below, extended from the east end of the house till opposite the western dredge; on this shaft were placed 4 pulleys, each arranged with clutch and lever, by which it could be thrown out of gear independently of the others, and the power was carried to the dredges by belts driven by these pulleys. The new dredge was mounted at the west end of the pier, and the dredge at the east end was also provided with buckets of the new pattern. These two dredges were worked through bevel gearing, the power being transmitted at any elevation by a pinion sliding on a vertical shaft; the other two were driven more directly by the belts, which were kept tight under all elevations by a loaded tightener sliding in a vertical frame; the latter arrangement proved the better one. Each dredge was completely boxed in between the second and third floors, to confine the splash, thus keeping the machinery and works upon the second floor dry and in good working order. The dredges discharged towards the north, the sand falling on inclined troughs which led to the lower platform, from which it was carried off in wheelbarrows, on runways built for the purpose, and deposited 100 ft. north of the works.

The machinery for handling stone was on the lower platform. It consisted of a railway and cars, the same which had been used at Pier No. 1, running along the west end of the works, and two travellers running lengthwise with the pier, between the wells and the sides of the caisson. A floating derrick was moored on the south side of the works, by which the stones were lifted from the stone barges and placed on the car; the car was then pushed under one of the travellers, the stone raised by a hand-crab which was placed at the east end of the works till it cleared the car, and drawn forward till opposite the desired point by a steam crab, which was likewise at the east end of the works, and driven by the same engine which worked the dredges, both sets of machinery rarely being worked together. This apparatus was not mounted till the beton in the two lower sections of the caisson had all been put in.

Soon after the caisson was brought into position the rectangular openings into the lower chambers had been surmounted by timber boxes; this was continued from time to time as the sinking progressed, the successive sections of these well walls being made of such a height as was found most convenient. When the hollow walls of the caisson had been filled with beton a second section was built above it; this section was an open frame structure, covered with 3-in. oak plank dressed in a planer, and similar to the caissons used at Piers 1 and 3; the long sides were given a batter of 1 in 16, but the short sides of the starlings were built plumb; additional lengths were also put on the gas pipes. This section, like the lower one, was filled with beton, about one-half the full amount being put in before starting the machinery. The beton was mixed upon the platform, thrown at once into the caisson, and beaten down with a paving maul. It set rapidly, forming a satisfactory compound; the caisson thus

* A patent for the improvement in these dredges was issued to the authors of this work, bearing date January 18, 1870.

became merely the covering of a single artificial stone or monolith, of the form most convenient for the work, and which carried the masonry of the pier above.

On the 11th of December the ice closed at the bridge line, and the river froze across. A week later the ice, which was still thin, began to rot rapidly under a strong sun, and on the 19th it broke up and went out. No serious damage was done, but a large sheet of ice, jamming above the draw rest, forced inwards the ice along the north shore, which, swinging on a pivot, about the anchor piles above the works, tore out two piles on the north-west corner of the false-works of this pier, the injury being done at one of those points where the exposure was supposed to be least. The damage was soon repaired ; one of the piles had only been bent over, and was drawn back into place ; the other, the corner pile, was destroyed, but the platform was made secure by bracing below.

On the 28th of December the machinery was started ; a few unimportant changes were found desirable, but its performance was, on the whole, very satisfactory. For the first week it was driven only by day, while the forces were being organized and drilled to their work. On Monday, the 4th of January, two gangs were put on, and the work proceeded both night and day. Each gang had a superintendent at its head, Mr. Tomlinson taking the day, and Mr. Bostwick the night shift ; a master of machinery had general charge of the 4 dredges, while two mechanics were assigned to the care of each dredge ; an engineman and fireman tended the engine on the lower floor, another man was given special charge of the donkey pump, and a spare machinist was employed upon odd jobs ; a large gang of laborers completed this force ; all the laborers worked under one foreman, and the majority of them were employed in wheeling off the sand, but 12 men were detailed to work the crabs on the top floor, and a few more to tend the suspension screws, while it occasionally became necessary to call in the entire force for the latter work. The same force was, of course, duplicated for the second shift ; each gang worked from 7 to 7 o'clock, the day gang being allowed an hour at noon for dinner, and the night gang being furnished with hot coffee at midnight.

Eight vertical rods, graduated into feet and tenths, were fastened on the sides of the caisson, one at each end and shoulder, and one in the middle of each long side ; they served as gauges to measure the descent, 8 blocks placed on the platform opposite them, at an elevation of 109, answering as reading fingers ; the gauge at the west nose was numbered 1, that on the south-west shoulder, 2, and so on continuously around the pier. The dredges were also numbered from 1 to 4—the new dredge at the west end being number 1. A full journal of the progress of the sinking was kept by the superintendent, from which a set of tables, illustrating the behavior of the pier and conditions of the sinking, were prepared. These tables, which give the best illustration of the actual working of the plan, are printed in Appendix E. ; they contain a statement of: 1st. The number of hours' work performed by each dredge, with the estimated daily excavation. 2d. The readings of the gauges, daily progress, and average elevation of the cutting edge. 3d. The soundings opposite each gauge, and average elevation of the sand surrounding the pier. 4th. The displacement and the actual and effective weights of the pier. 5th. The area of the surface in contact with the sand, and the effective weight for each square foot of such surface in contact, with estimated friction.

The material dredged was at first a soft sticky silt, which could be handled only in connection with a large amount of water in the form of a thin, flowing mud. The work was conducted very carefully, the gauges were constantly watched, and the screws were tended continually ; with these precautions little difficulty was experienced in keeping the pier true ; after it had been sunk 10 or 12 feet the surrounding sand answered as a guide, and less care was required to regulate the descent. Owing to the weight of the pier and the care with which the machinery had been arranged, the sinking proceeded at a very much more rapid rate than had yet been accomplished with the bottomless caissons, and exceeded the expectations of the engineers. On the 6th of January, only two days after both shifts of men had been put on, the work had to be suspended, because the beton could not be put in fast enough to keep pace with the descent, and from this time forward the

chief difficulty lay in building up the pier rather than in sinking it. The water jets were found to be of less service than had been anticipated, the wedge-shaped edges feeding the sand to the dredges without their assistance; streams of water were occasionally passed through the pipes at the nose and shoulders, and all the outside pipes were lengthened as the height of the caisson was increased, but those in the cross-walls were allowed to be buried up in the beton.

On the 7th the machinery had to be stopped again, and it remained idle nearly a week; on the 8th the beton was nearly all in, reaching to the top of the second section. A third section had meanwhile been added, 12 ft. high, the end walls of which were at first made only one-half this height, to facilitate handling the stone. On the 9th the river rose about a foot, causing a strong current on the south side of the works, which was found to have increased the depth of water from 9 to 17 ft., so that the pier began to settle over slightly, till held by the suspension screws; 150 gunny bags were filled with sand and thrown overboard among the piles and along the side of the caisson, which suspended the scour.

On the 13th the masons began work, laying the first course of stones on the hardened surface of the beton; in the evening of the same day the dredgers were again set in motion, and the work of sinking resumed. The following day the river began to rise again, repeating the scour of the preceding week; the wash was again restrained by the use of sand bags, over 500 of which were thrown around the works on this and the two succeeding days. This method of protection was found effective, while it was free from the objections which prevented the use of riprap; if stones had been thrown around the pier it was feared that they might work under the edge of the caisson and obstruct the descent; the sand bags might also work under the edge, but their soft and yielding nature would prevent their doing harm; some of them did actually find their way inside of the caisson, and one was brought up in a dredge bucket uninjured.

It being found impossible to lay masonry as fast as the dredges could sink the caisson, the plan was adopted of running the machinery only by night, and giving the masons every convenience for work by day. Mr. Tomlinson then took charge of the night shaft, and the pier was sunk for the remaining distance under his directions. The masons were often unable to do more than set the face stones of a course, together with a few of the heavier pieces of backing, in a day, in which case the night force would be employed during the first hours of their shift in backing up with beton. The material excavated had changed to a coarse sand which was easily handled, each dredge throwing six full buckets in a minute; the pier also settled more rapidly than hitherto, sinking 5 in. in an hour when everything was working well. The lower platform and the second floor were lighted by locomotive head-lights, which threw a strong glare over the works and men, and a visit to the pier late in the evening, when the machinery was all working to its best advantage, and half an hour showed a decided settlement, became a very interesting thing.

On the 19th, a pile top was found buried in the sand below dredge No. 2, which was secured by a diver and drawn out with little trouble. The next day some timber, supposed at first to be the branches of a large snag or tree, was discovered under the lower end of the caisson. An additional diver was sent for, and after a few days' delay the log was cut through and drawn out, when it was found to be a broken pile, probably belonging to the works of the wrecked foundation. Another old pile was found near it, which extended from outside of the caisson nearly to the centre of the eastern chamber, passing under the cutting edge; a line was made fast to it and attached to a set of falls to the upper falseworks, and held in this manner while the sinking proceeded; on the 1st of February, this pile broke off under the cutting edge and was drawn up through the well hole; it proved to be a stout hickory stick, nearly a foot in diameter, and showed a rough broom-like fracture; it had been carried down with the caisson several feet before breaking, and the outside portion still remained under the edge, where it was found by a diver when the caisson had nearly reached the rock. While the divers were at work upon these sticks, it became necessary to jet away the sand around them, thus forming a cavity close

to the edge of the caisson; in two or three instances this caused sand slides, the sand suddenly caving in, filling up the cavity and raising the water in the wells; at one time the water in the wells was raised 3 ft. above the level of the river, when the soundings showed a hole 10 ft. deep outside the caisson, over the point where the slide occurred; this, however, was soon filled up by caving in and by fresh deposits.

On the 3d of February, the masonry was finished to the top of the sill of the fourth section, which had now been added, or 39 ft. above the cutting edge; as this was less than 2 ft. below the point at which the ice-breaker courses were to be started, it was thought best to lay nomore masonry till a permanent bearing had been reached upon the rock. Borings recently taken had found the rock at an elevation of 56.6, though the auger had apparently been disturbed by loose stones 3 or 4 ft. before it reached that depth. In the evening of the 4th the pier settled rapidly; the machinery had never worked better, and 6 in. descent was noticed in an hour; but at midnight it came against some hard substance and almost stopped. The diver at first reported rock, but the pier went down 9 in. during the next 3 days, and though the dredges threw out a large number of loose stones, the obstruction was found to be a mass of clay under the south edge; the upper section was filled with sand, and under the pressure of this additional weight, 17 in. more descent was obtained. It was evident, however, that the bed rock was covered with about 3 ft. of loose stones mixed with a moderate quantity of stiff blue clay; the foundation would probably have been perfectly safe if kept where it was, but it was still thought best to place it directly upon the rock.

An additional number of divers were engaged, and on the 16th of February, a force of 8 divers, with 4 air-pumps and the proper complement of tenders, was ready for the work; they were divided into 2 gangs, and the work was prosecuted both night and day, one man working in each chamber. The depth of water in the wells was about 50 ft., and to render the work less burdensome, the water was warmed by sending steam down the water jet pipes. The stones were removed singly from under the edge, piled up in the centre of the walls, and placed in the dredge buckets; the dredges were worked for a short time after the divers had come up, bringing up the smaller stones; the largest rocks were left below. The stones were of all sizes, from small pebbles to boulders containing 2 or 3 cubic feet; the larger ones were mostly of limestone, and showed few or no signs of wear; the smaller pebbles were well rounded, and of diverse geological character, presenting a strange collection of the different formations found on the eastern slope of the Rocky Mountains; sandstone, granite, moss agates, and many other minerals were mixed in wild confusion, while bits of water-charred wood, reduced almost to pure coal, and several varieties of teeth, were found among them; an Indian arrow head was also picked out of the lot.

On the 10th of March the rock was reached, at the elevation of 56.6. A hole was drilled into it 5 ft., as had been done at the 3 other channel foundations, and no sign of any flaw or weakness discovered. A row of bags, filled with freshly mixed beton, was placed around the edge, as had been already done at 2 of the other foundations, and the dredges were removed and the wells filled up with beton, laid under water, with the same boxes that had previously been used at Pier No. 2. Divers were still employed, to make sure that the beton filled up the whole space of the lower chambers, packing well in towards the edges, and covering the boulders which had been left piled in the centre; the sand was thrown out from above the masonry, and the upper sections of the well walls were torn away, to secure a good bond between the masonry and the filling of beton.

The layer of boulders had been the cause of considerable delay, while it had also been productive of some additional expense; but the character of the larger stones, which, by their roughness, showed that they were seldom, if ever, disturbed by the water, indicated the perfect security of a foundation put in at this depth; and the mere presence of such material was equivalent to 3 ft. of riprap protection around the base of the pier.

The false-works were stripped, the trusses taken down, and on the 26th of March nothing remained above the lower platform. A 5th section was added to the caisson as a security against any rise in

the river; a derrick was mounted on the platform on the north side of the pier; on the 2d day of April the laying of masonry was resumed and the pier was built up at once.

This foundation, which from its situation might fairly be regarded as much the most difficult on the work, became, in its final execution, the most successful of all, and was put down in a less time than was consumed on any other deep foundation. The plan here adopted is believed to admit of wide application; and, while it is more expensive than the simple foundations which are used in ordinary streams, it becomes a cheap method of founding in deep and unstable bottoms. By slight modifications it can be combined with the pneumatic process, in such a way as to allow extraordinary obstacles to be removed by men, while the entire sand excavation is made by machinery. It is also applicable to foundations of extraordinary depth, where the pneumatic process must fail from the inability of the men to stand the air pressure; it could be carried to a depth double that to which pneumatic tubes or caissons have been sunk, with the occasional use of the air chamber for a very short time; and if this be entirely dispensed with, it may even be extended to a depth of several hundred feet in clean sand, or with machinery sufficiently heavy to remove obstacles.

## EXPERIMENTS UPON THE STRENGTH OF DIFFERENT SYSTEMS OF BRICK AND CEMENT FLOORS.

From "Extraits des Annales du Conservatoire" through "Revue Industrielle."

M. Garcin proposes to replace the brick work ordinarily employed between the iron beams of fire-proof floors by a system of voussoirs of plaster, forming by their union a resemblance to a course of free-stone.

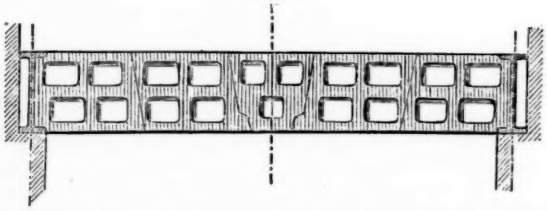
The voussoirs are pierced with regular openings to reduce their weight. Each course is formed of 5 voussoirs, with inclined sides, each having 4 tubular openings except the key-stone, which has but 3. The extreme blocks rest upon a double T beam, the hollow side of which they fit accurately. These blocks, employed with joints of plaster, form arches, which M. Garcin has submitted to tests, to compare their strength with the other systems which are employed in a similar manner.

For this purpose two double T beams were held securely by bolts parallel to each other, and 0.745 m. apart. The height of the beams was 0.12 m. Between these beams arches of several different systems or kinds of material were built, each having a span and thickness corresponding to the supports, and a length of 0.45 m.

Some days after, each was placed horizontally be ween two supports, and secured by wooden wedges in an embrasure in such a manner as to prevent any flexure of the iron beams.

Each was then loaded with boxes, containing iron balls, along the centre of each arch to the breadth of 0.37 m., or half the span.

FIG. 1.



The first tried was an arch of Garcin's system (Fig. 1), made in cement three weeks previously. It presented a surface of 0.745 m. $\times$ 0.45 m. = 335 sq. metres, and weighing 41.3 kilogrammes, which is equal to 123.3 kilogrammes per sq. metre.

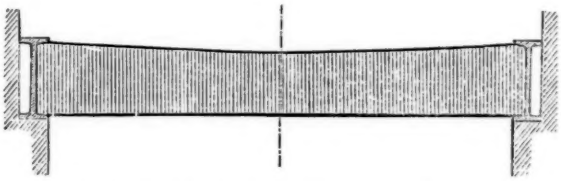
The second was of plaster, the same system and the same age as the first, and

weighing 102.4 kilogrammes to the sq. metre.

The third example was of ordinary plaster, slightly trough-shaped, so that the thickness at the middle of the span was only 0.095 m., and the weight 130.5 kilogrammes per sq. metre. (See Fig. 2.)

The fourth trial was upon a system

FIG. 2.

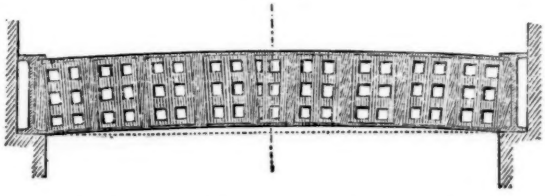


formed of hollow bricks, laid with plaster joints, without cambre, and weighing 128.7 kilogrammes per sq. metre.

The fifth was formed of bricks, of the same kind as the last, forming an arch, with a versed sine of 0.010 m., obtained by the aid of inclined joints, with a wedge-shaped key-stone; weight, per sq. metre, 143.6 kilogrammes. (See Fig. 3.)

These two latter specimens had each 9

FIG. 3.



bricks in the span, the bricks weighing 1,960 kilogrammes to the 1,000, and laying (edgewise) 55 to the sq. metre.

The test load in each case has been carefully increased up to the point of rupture.

The following table exhibits the results of these experiments :—

| NO. | SYSTEMS EXPERIMENTED UPON. | BREAKING WEIGHT IN KILOGRAMMES. | BREAKING WEIGHT PER METRE. KILOGRAMMES. | WEIGHT OF MASONRY PER SQ. METRE. KILOGRAMMES. |
|---|---|---|---|---|
| 1 | Garcin's System in Cement..... | 736 | 2340 | 123.3 |
| 2 | " " Plaster..... | 880 | 2790 | 102.4 |
| 3 | Ordinary " Plaster..... | 592 | 1880 | 130.5 |
| 4 | " " Brick, without arching | 1448 | 4720 | 128.7 } 136.2 |
| 5 | " " " slightly arched | 1824 | 5790 | 143.2 } |

The third and fourth columns show the comparative advantages of the different systems.

The voussoirs of M. Garcin weigh 102.4 kilogrammes per sq. metre, but their ultimate resistance is only 2,790 kilogrammes.

The systems in brick work weigh 136 kilogrammes, but they resist up to 5,790 kilogrammes weight. These figures show for each of these systems their relative security, and afford suggestions as to the method of judiciously employing each.

THE "Post" thus sums up the manufacturing interests of Detroit: Capital invested, $10,000,000; value of annual productions, $21,000,000; amount of wages to laborers and mechanics, $5,000,000; number of employees, 9,000.

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A BLAST furnace is soon to be erected near Zanesville, Ohio, which, when completed, will give employment to 150 men.

## THE FOSBERRY MITRAILLEUR.

From "Engineering."

Were we desirous of writing the history of the progress of invention as affecting munitions of war, we should turn neither to the records of the Patent Office for the last 20 years, nor to contemporaneous history for the same period, for materials, although both teem with matter pertinent to the subject. But that very matter is, for the most part, such a tangled mass, and the line of demarcation is in many instances so very faintly drawn between the rights of one inventor and those of his neighbor, that the task of assigning to each his just due would be simply impossible. Besides, a compiler of history must deal with facts and not fancies, and for every one of the former he would find a score of the latter in the sources to which we have above referred, and he would there find nothing to assist him in discriminating between the one and the other. Now, a fact is a reality, a thing done, an aim accomplished, an idea brought into tangible shape, and, above all, into practical use. Hence, if we would note the actual and absolute progress made in our war *materiel*, we must take our stand upon the battle-fields of modern times, for we shall find each one to constitute a new era in the art of war. Each will be found to be marked by the practical introduction of one new agent of destruction or another, the development of which, however, is generally due to times of peace. Thus the French campaign in Italy saw the remarkable results to be attained by rifled guns; the American war developed iron-clads, monitors, torpedoes, and repeating rifles. When Prussia and Austria met as foes, their struggle taught nations the value of breech-loading small arms, and we now have the hostilities between France and Prussia evoking the capabilities of the mitrailleur.

It is with this weapon that our present remarks mainly have to do—not, however, the mitrailleur as in use in the French army, but one which is now being tried in England, and which is attracting considerable attention just now. And, first, a few words in brief as to the history of this arm, whose name carries such terror with it. If our readers will turn to page 270 of our third volume, they will there find an illustrated description of the Gatling gun, one of the earliest of this class, and the general principles of which are embodied in the mitrailleur. These principles are a group of barrels banded together, a breech arrangement for rapid loading and firing, and means for vertical and horizontal training. About the same time that the Gatling gun appeared, or shortly afterwards, we had the Belgian mitrailleur, the invention of M. Montigny. Subsequently to this again, there appeared in France a similar weapon, invented by M. Manceaux, although, we believe, the weapon used in the present war is that of M. Montigny, with some slight alterations in the rifling and ammunition. Prussia and Austria procured samples of the Belgian arm and placed it in the hands of committees. No steps, however, were taken by England in the matter until Major Fosberry, V. C. stirred up the question, and went to Belgium to study the weapon. Satisfied with its capabilities, when properly constructed, Major Fosberry at once set about improving it, for he found it roughly made, the rifling bad, and the ammunition defective. Having obtained its recognition by our Government, a mitrailleur was constructed, into which numerous detail improvements were introduced by Major Fosberry, and this weapon has recently been the subject of some preliminary experiments at Shoeburyness.

Before noticing these experiments and their results, it may be as well to give a general description of the Fosberry mitrailleur. A detailed description it is neither possible nor expedient to give at present, inasmuch as on visiting Shoeburyness a day or two since we found the mitrailleur had been taken to pieces in order to make various slight alterations, the necessity for which had been rendered apparent by the recent practice. And it is possible that still further alterations will have to be made before the weapon is perfect, so that, under the circumstances, we wonder the authorities allowed the public to see it at all; their courtesy certainly deserves acknowledgment. The Fosberry mitrailleur consists of a compound barrel, composed of 37

## TABLE OF RESULTS.

*First Day's Experiments—Series* 1 *to* 12.

| Number of Series. | Name of Weapon. | Range in Yards. | Nature of Fire. | Number of Rounds Fired. | Time in Minutes. | Total Number of Hits. | Number of Men placed *hors de combat.* Cavalry or Infantry. | | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | m. s. | | | | |
| 1 | Mitrailleur . | 800 | volley | 6 | 2 00 | 110 | 38 | 45 | Eight cartridges failed. |
| 2 | Mitrailleur . | 800 | quick file | 5 | 1 00 | 154 | 59 | 49 | Three cartridges failed. |
| 3 | Muzzle-loading field gun 9-pdr. | 800 | .... ..... | 5 | 2 00 | 118 | 24 | 27 | Shrapnel fuzed with wood, time fuzes, One burst too short for effect, and one burst through the target. |
| 4 | Ditto..... | 800 | ..... | 8 | 2 00 | 115 | 45 | 51 | |
| 5 | Breach-loading field gun 12-pdr. | 800 | ..... | 6 | 2 00 | 38 | 15 | 18 | Segment shells and C percussion fuzes. Two shells burst behind targets. |
| 6 | Ditto..... | 800 | ..... | 5 | 2 00 | 15 | 8 | 5 | Shrapnel shells and time fuzes. Two rounds 200 yards short, two over, one *nil* from fuze blowing. All high in air at burst. |
| 7 | Mitrailleur . | 600 | File with horizontal motion | 6 | 2 00 | 127 | 61 | 57 | Sixteen cartridges failed. |
| 8 | 9-pounder . | 600 | ..... | 7 | 2 00 | 283 | 68 | 88 | Shrapnel and wood time fuzes. |
| 9 | 12-pounder . | 600 | ..... | 7 | 2 00 | 142 | 48 | 58 | Shrapnel and time fuzes. |
| 10 | Mitrailleur . | 300 | File with horizontal motion | 5 | 2 00 | 171 | 60 | 69 | |
| 11 | 9-pounder . | 300 | ..... | 10 | 2 00 | 208 | 75 | 79 | Case shot, 120 bullets each. |
| 12 | 12-pounder.. | 300 | ..... | 9 | 2 00 | 268 | 91 | 111 | Case shot. |

*Second Day's Experiments—Series* 13 *to* 24.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 13 | Mitrailleur.. | 400 | Sharp file with horizontal motion | 6 | 2 00 | 178 | 73 | 84 | |
| 14 | 12-pounder.. | 400 | ..... | 9 | 2 00 | 168 | 72 | 79 | Case shot. Tenth round not got off; miss-fire of friction tube. |
| 15 | 9-pounder.. | 400 | ..... | 11 | 2 00 | 236 | 77 | 86 | Case shot. |
| 16 | 9-pounder.. | 400 | ..... | 7 | 2 00 | 144 | 54 | 66 | Shrapnel, with five seconds' fuze cut to 1½ seconds to test results in comparison with case. |
| 17 | Mitrailleur.. | 400 | single shots... | 5 | 3 50 | 177 | 83 | 74 | Deliberate firing. Horizontal training; 185 bullets thrown. |
| 18 | 9-pounder.. | 400 | ..... | 5 | 1 14 | 110 | 52 | 59 | 550 bullets thrown |
| 19 | 12-pounder.. | 400 | ..... | 7 | .. | 118 | 47 | 58 | Case shot; 9 not taken; 2 cases did not break up; 690 bullets thrown. |
| 20 | Mitrailleur.. | 300 | single shots... | 5 | 2 55 | 172 | 92 | 83 | Horizontal training; 185 bullets thrown. |
| 21 | Ditto..... | 600 | Single shots and a volley | 5 | 1 55 | 107 | 49 | 52 | 185 bullets thrown. |
| 22 | Ditto..... | 800 | Ditto ..... | 5 | 1 45 | 106 | 40 | 45 | 185 bullets thrown. |
| 23 | 12-pounder.. | 300 | ..... | 6 | 1 50 | 138 | 58 | 59 | Case shot. One round did not break up. |
| 24 | 9-pounder.. | 300 | ..... | 5 | 1 05 | 162 | 58 | 64 | Firing case; 550 bullets thrown. |

rifled tubes, each of which is about the size of an ordinary Enfield rifle barrel. These tubes are hexagonal on the outside, and are thus closely fitted together, the whole series being enclosed in a cylindrical iron casing and forming one weapon. The barrels are open at the breech ends, and are closed by a breech block, which, for loading, is drawn back, and a metal plate containing 37 central fire cartridges is inserted vertically. The firing apparatus is carried in the breech block, and consists of 37 pistons or strikers, each actuated by a spiral spring. After the metal plate containing the cartridges has been inserted, the breech

block is pressed forward by a lever, the cartridges being thus forced forward into the chambers of the barrels. The act of closing the breech block places the springs of the strikers in tension, and they are freed by the descent of a serrated shutter actuated by a firing lever. According as this lever is worked, quickly or slowly, the firing is either like volley firing or file firing, or even single shots can be made. The mitrailleur, at the same time, can be trained horizontally so as to traverse the whole front of an advancing column. The mitrailleur is mounted on a timber field carriage, which, although full heavy for it, gives its steadiness and absorbs the recoil; a lighter carriage, may, however, yet be adopted. The cartridges used were metal-cased and paper-covered, having a central fire, and generally resembling the Boxer cartridges used for the Snider rifle.

The experimental trials commenced on the 11th instant, and were continued throughout that and the following day. They were comparative, being carried on against the 12-pounder breech-loading rifled field gun, and the 9-pounder muzzle-loading (Maxwell) Indian bronze field piece. The design was to ascertain the relative powers of the mitrailleur and the field guns for repelling an attack of infantry or cavalry advancing in line or column. With this view a line of wooden targeting, on which 150 infantry in front of 90 cavalry were depicted in outline. The ranges were 300, 400 600, and 800 yds. respectively, and the shooting was at first made against time at known ranges, no allowance being made for any hitches in handling or in the service of the several weapons. Two minutes' time was allowed in each case. The annexed Tables show the results of each day's proceedings at a glance, the details of the actual practice being given. There were 12 series each day, or 24 series in all.

It is worthy of note that this is the first occasion on which shrapnel shell has been fired at such short ranges. At the commencement of the series No. 16, only one of all the figures on the target remained unhit. This one was struck during that practice by a splinter on the cheek. The practice for rapidity was included in series 1 to 16, after which the previous series were repeated deliberately in order to eliminate failures due to premature or bad fuzes, defects in mitrailleur ammunition, and other unforeseen circumstances. Taking the results of the experiments as they stand, they are not altogether satisfactory as regards the mitrailleur so far as they have gone. It was said that the mitrailleur could accomplish 10 rounds per minute, whereas it has as yet only delivered 3. The 9-pounder field-gun—a muzzle-loader—gave 11 rounds in two minutes; whilst the mitrailleur never got off more than 6. But it is to be borne in mind that the latter weapon is not working with its maximum effect. The cartridges are not properly adapted to the gun, and cause delays both in loading and in withdrawing the cases. Sometimes the cartridges stuck in the chambers; at others the burr of the metal foil round the bullet caused the crumpling up of the cartridge case, and prevented the breech block closing. A metal case without any paper or other coating would probably do away with all these obstructions. Again, if we look at the number of bullets thrown in a given time, we do not find in the mitrailleur such a preponderance as we might have expected. Six discharges, accomplished in two minutes, deliver 222 bullets; the Indian gun, however, firing case shot, launches 110 bullets at each discharge, and as this gun has fired ten rounds in two minutes, we thus have 1,100 bullets delivered, or about five times as many bullets as discharged by the mitrailleur. The latter arm, however, shows a much higher percentage of hits than the field gun, and this with all the drawbacks attendant upon the unsuitable cartridges. The fact is, the Fosberry Mitrailleur is only going through the experimental stage at the present time, and when certain minor defects of construction have been remedied, and suitable cartridges supplied, we may look for far better results. Properly developed, the mitrailleur will undoubtedly prove one of the most powerful and useful weapons modern times have seen.

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CERIUM.—This metal was discovered by Berzelius and by Kloproth, in 1803, in a peculiar ore found in an iron mine in Sweden. The name cerium was given because in the same year an asteroid had been discovered and called Ceres.

# FORMULÆ FOR STRAINS IN TRUSSES, AND THEIR PRACTICAL APPLICATION.

(*Continued from page* 216.)

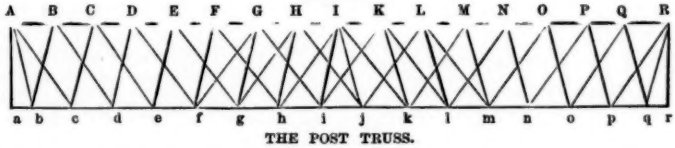
The Whipple or Linville Truss, illustratrated in Example 2d, is a compound truss, and in this respect differs very materially from the other examples. As there mentioned, it is a combination of two simple and similar trusses, which act, as far as all the members affected by vertical strains are concerned, entirely independently of each other. This independence is as complete as if they were on opposite sides of the bridge, and extends fully to the counterbracing. A separate consideration of these simple trusses renders the determination of the strains much easier.

The superiority or greater lightness of a compound truss is owing largely to the division of the weight between two sets of struts. In a simple truss, one set of vertical and inclined members is subject to the whole weight.

*Example 4th.*

This, the Post Truss, is also a compound truss, but very different from Example 2d. The simple trusses of which it is composed act independently of each other only under a full load. The counterbracing connects them and a passing load is not equally divided between them as in the other case.

FIG. 14.



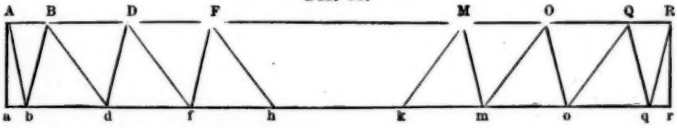

THE POST TRUSS.

The load is on the bottom chord, struts inclined with run of half a panel, and ties have a run of a panel and a half.

Omitting all the counterbracing, one simple truss is shown in Fig. 15.

This truss bears one half the load when

FIG. 15.




the bridge is fully loaded, but is irregular and has the weight unevenly distributed. The points $k$, $m$, and $o$, each bear a full panel load, but from Fig. 14 it may be seen that the point $q$ bears half the load between $q$ and $r$, and half the load between $p$ and $q$, which is three-fourths of the load borne by the other points, $k$, $m$ and $o$; and $r$ bears directly one-fourth of a panel load. Eq. 11.

$$H' = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,l},$$

requires some change before application.

Let $l = 200$ ft., the length of the truss.
$d = 18.75$ ft., the depth of the truss.
$w = 150{,}000$ lbs., the weight of the truss.
$w' = 300{,}000$ lbs., the weight of a full uniform load.
$p = 12.5$ ft., length of panel of compound truss.
$x$ = distance of any one of the points $q$, $o$, $m$, $k$, from the right abutment.

$\frac{(w'+w)\,x}{4}$ is the moment of the abutment at any point, $x$. The moment of the load on the section $x$ is

$$\frac{(w'+w)}{2\,l}\left(x-\frac{5\,p}{2}\right)\left(\frac{x}{2}-\frac{p}{4}\right)+\frac{p(w'+w)}{l}\left(x-\frac{3\,p}{8}\right),$$

$$=\frac{(w'+w)\,x^2}{4\,l}+\frac{(w'+w)\,p\,x}{4\,l}-\frac{(w'+w)\,p^2}{16\,l}$$

Whence

$$H=\frac{(w'+w)\,x}{4\,d}-\frac{(w'+w)\,x^2}{4\,d\,l}-\frac{(w'+w)\,p\,x}{4\,d\,l}+\frac{(w'+w)\,p^2}{16\,d\,l} \qquad (31)$$

This equation gives the horizontal strains in the upper chord of Fig. 15, in

the members opposite the points $k$, $m$, $o$, and $q$.

To find the strains in the lower chord of the same simple truss, let $x'$ represent the distance of any one of the points Q, O, M, and K from the right abutment; the moment of the load on $x'$ is

$$\frac{(w'+w)}{2l}(x'-p)\left(\frac{x'}{2}-p\right)+\frac{p\,(w'+w)}{l}\left(x'-\frac{3\,p}{8}\right)$$
$$=\frac{(w'+w)\,x'^2}{4\,l}+\frac{(w'+w)\,p\,x'}{4\,l}+\frac{(w'+w)p^2}{8\,l},$$

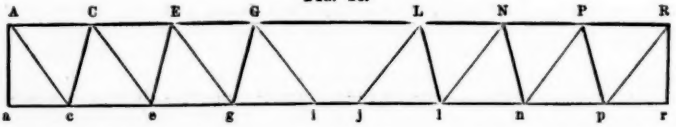
Whence

$$H=\frac{(w'+w)\,x'}{4\,d}-\frac{(w'+w)x'^2}{4\,d\,l}-\frac{(w'+w)\,p\,x'}{4\,d\,l}-\frac{(w'+w)\,p^2}{8\,d\,l} \quad (32)$$

The amount of horizontal strain in the members of the lower chord opposite the points Q, O, M and K.

Omitting all counterbracing, the other truss is shown in Fig. 16.

Fig. 16.




This truss bears the same weight as the other, but no part of the weight rests directly on $r$, but is borne equally by the points $j$, $l$, $n$ and $p$.

The moment of the abutment is $\frac{(w'+w)x''}{4}$, $x''$ being the distance of any of the points $j$, $l$, $n$ and $p$, from the right abutment.

For strains in the upper chord, the moment of the load on the section $x''$ is,

$$\frac{(w'+w)}{2\,l}\left(x''-\frac{3\,p}{2}\right)\left(\frac{x''}{2}+\frac{p}{4}\right)$$
$$=\frac{(w'+w)x''^2}{4\,l}-\frac{(w'+w)\,px''}{4\,l}-\frac{3\,(w'+w)p^2}{16\,l}$$

Whence,

$$H=\frac{(w'+w)\,x''}{4\,d}-\frac{(w'+w)\,x''^2}{4\,d\,l}+\frac{(w'+w)\,p\,x''}{4\,d\,l}+\frac{3\,(w'+w)\,p^2}{16\,d\,l}. \quad (33)$$

The amount of horizontal strain in the upper chord members opposite the joints $j$, $l$, $n$ and $p$.

For strains in the lower chord, $x'''$ being the distance of any one of the points L, N and P, from the right abutment,

$$H=\frac{(w'+w)x'''}{4\,d}-\frac{(w'+w)x'''}{2\,d\,l}\left(\frac{x'''}{2}-\frac{p}{2}\right)$$
$$=\frac{(w'+w)x'''}{4\,d}-\frac{(w'+w)x'''^2}{4\,d\,l}+\frac{(w'+w)\,p\,x'''}{4\,d\,l} \quad (34)$$

The strains in the upper chord of the compound truss can be obtained by adding equations (31) and (33), making $x$ of one equation equal to $x+p$ of the other, as in Example 2d. In the Whipple Truss, however, the result was the same; if $x+p$ was substituted in either of the equations for the horizontal strains in the upper chord of the simple truss and then added to the other, we obtained only one equation for the horizontal strains in one chord. But this is not true in the Post truss; if $x''$ of equation (33) be made equal to $x+p$ and added to equation (31) we obtain a different result from what is obtained when $x$ is made equal to $x''+p$ and the two equations then added. We have, therefore, two equations for the horizontal strains in the upper chord, one for the values of $x$, the other for the values of $x''$. In like manner, we have two equations for the lower chord, one for the values of $x'$, the other for the values of $x'''$.

Making $x''$ of equation (33) equal to $x+p$ of equation (31), and adding the two, we obtain

$$H=\frac{(w'+w)x}{2}-\frac{(w'+w)x^2}{2\,d\,l}+\frac{(w'+w)\,p}{4\,d}-\frac{(w'+w)\,p\,x}{2\,d\,l}+\frac{(w'+w)\,p^2}{4\,d\,l} \quad (35)$$

for the strains in the upper chord of full truss opposite $q$, $o$, $m$, $k$, $h$, $f$, $d$, and $b$.

Substituting the values of the constants, we get

$H = 11250\,x - 60x^2 + 79687.5.$

When $x = 6.25$

$H = 70312\ 5 - 2343.75 + 79687.5 = 147656.25$ lbs.

Compression in Q R and A B.

The next value of $x$ in this equation is 31.25.

$H = 351562.5 - 58593.75 + 79687.5 = 372656.25$ lbs.

Compression in O P and C D.

The next value of $x$ is 56.25.

$H = 632812.5 - 189843.75 + 79687.5 = 522656.25$ lbs.

Compression in M N and E F.

The next value of $x$ is 81 25

$H = 914062\ 5 - 396093.75 + 79687.5 = 597,656.25$ lbs.

Compression in K L and G H.

In equation (31) make $x = x'' + p$, add the equation so changed, to equation (33) and we obtain

$$H = \frac{(w'+w)\,x''}{2\,d} - \frac{(w'+w)\,x''^2}{2\,d\,l} - \frac{(w'+w)\,p\,x}{2\,d\,l} + \frac{(w'+w)\,p}{4\,d} - \frac{(w'+w)\,p^2}{4\,d\,l} \quad (36)$$

for the strains in the upper chord of the compound truss opposite the points of single truss (Fig. 16) *p*, *l*, *n*, *j*, *i*, *g*, *e*, and *c*.

Substituting the values of the constants, we have

$H = 11250\,x'' - 60\,x''^2 + 70312.5.$

Giving $x''$ its first value, 18.75.

$H = 210937.5 - 21093.75 + 70312.5 = 260156.25$ lbs.

Compression in P Q and B C.

The next value of $x''$ is 43.75.

$H = 492187.5 - 114843.75 + 70312.5 = 447656.25$ lbs.

Compression in N O and D E.

The next value of $x$ is 68 75.

$H = 773437.5 - 283593.75 + 70312.5 = 560156.25$ lbs.

Compression in L M and F G.

The next value of $x''$ is 93.75.

$H = 1054687.5 - 527343\ 75 + 70312.5 = 597656.25$ lbs.

Compression in I K and H I.

In adding equations (32) and (34) to obtain the tensions in the lower chord of the double truss, we must, for similar reasons as before, make $x$ in one equation equal to $x - p$ in the other equation, to obtain the tension opposite the points in that simple truss to which the latter equation belongs.

In equation (34) make $x''' = x' - p$ of equation (32), add the two equations and we obtain

$$H = \frac{(w'+w)\,x'}{2\,d} - \frac{(w'+w)\,x'^2}{2\,d\,l} - \frac{(w'+w)\,p}{4\,d} + \frac{(w'+w)\,p\,x'}{2\,d\,l} - \frac{5\,(w'+w)\,p^2}{8\,d\,l} \quad (37)$$

for the strains in the lower chord opposite the points Q, O, M, K, H, F, D and B.

Substituting the values of the constants,

$H = 12750\,x' - 60x'^2 - 86718.75.$

The first value of $x'$ is 12.5.

$H = 159375 - 9375 - 86718.75 = 63281.25$ lbs.

Tension in *b c* and *p q*.

Next value of $x'$ is 37.5.

$H = 478125 - 84375 - 86718.75 = 307031.25$ lbs.

Tension in *n o* and *d e*.

Next value of $x'$ is 62.5.

$H = 796875 - 234375 - 86718.75 = 475781.25$ lbs.

Tension in *l m* and *f g*.

Next value of $x'$ is 87 5.

$H = 1115625 - 459375 - 86718.75 = 569531.25$ lbs.

Tension in *j k* and *h i*.

In equation (32) make $x' = x''' - p$ of equation (34), add the two equations and we obtain

$$H = \frac{(w'+w)\,x'''}{2\,d} - \frac{(w'+w)\,x'''^2}{2\,d\,l} - \frac{(w'+w)\,p}{4\,d} + \frac{(w'+w)\,p\,x'''}{2\,d\,l} - \frac{(w'+w)\,p^2}{8\,l\,d} \quad (38)$$

for strains in the lower chord opposite the points P, N, L, I, G, E, and C.

Substituting the values of the constants,

$H = 12750\,x''' - 60\,x'''^2 - 77343.75.$

The first value of $x'''$ in this equation is 25.

$H = 318750 - 37500 - 77343.75 = 203906.25$ lbs.

Tension in *o p* and *c d*.

Next value of $x'''$ is 50.

$H = 637500 - 150000 - 77343.75 = 410156.25$ lbs.

Tension in *m n* and *e f*.

Next value of $x'''$ is 75.

$H = 956250 - 337500 - 77343.75 = 541406.25$ lbs.

Tension in *k l* and *g h*.

Next value of $x'''$ is 100,

$H = 1275000 - 600000 - 77343.75 = 597656.25$ lbs.

Tension in *i j*.

In Example 2d the calculation of the vertical strains was a very simple operation as equation (25) had only to be divided by 2. In the truss under consideration the simplest method will be, first to ascertain the constant strains resulting from the weight of the truss alone, and afterward the strain from the passing load.

For the truss in Fig. 15, the vertical equation (14) assumes the form

$$V = \frac{w}{4} - \frac{w}{2\,l}\left(u + \frac{p}{2}\right) \quad (39)$$

$u$ being the distance from the abutment to a point midway between the loaded points or ends of the panels of the simple truss.

For the truss in Fig. 16 equation (14) assumes the form

$$V = \frac{w}{4} - \frac{w}{2\,l}\left(u' - \frac{p}{2}\right) \quad (40)$$

$u'$ being the distance to the centre of any panel of this truss.

Substituting the values of the constants in equation (39),

$$V = 37500 - 375\left(u + \frac{p}{2}\right).$$

In panel $k$ M $m$, $u + \frac{p}{2} = 75$.

Whence V = 9375 vertical strain in panels $k$ M $m$ and $h$ F $f$ and their members $k$ M, M $m$, $h$ F and F $f$.

9375 × 1 414 (secant of the angle of the ties) = 13256.25 lbs.
Tension in k M and $h$ F.

9375 × 1.0541 (secant of the angle of the struts) = 9882.19 lbs.
Compression in M $m$ and F $f$.

Next value of $u + \frac{p}{2} = 50$.

V = 18750.

18750 × 1.414 = 26512 5 lbs.
Tension in $m$ O and $f$ D.

18750 × 1.0541 = 19764.37 lbs.
Compression in O $o$ and D $d$.

Next value of $u + \frac{p}{2} = 25$.

V = 28125.

28125 × 1.414 = 39768.75 lbs.
Tension in $o$ Q and $d$ B.

28125 × 1.0541 = 29646.56 lbs.
Compression in Q $q$ and B $b$.

In part of panel $q$ R $r$.

$u = o$ and V = 35156.25 lbs.
Compression in A $a$ and R $r$.

35156.25 × 1.0541 = 37058.2 lbs.
Tension in $q$ R and A $b$.

In truss, Fig. 16,

$u' - \frac{p}{2}$ has the same values as $u + \frac{p}{2}$

and when $u' - \frac{p}{2} = 75$.

13256.25 lbs. Tension in $j$ L and G $i$.
9882.19 lbs. Compression in L $l$ and G $g$.

Next value of $u' - \frac{p}{2} = 50$.

26512.5 lbs. Tension in $l$ N and $g$ E,
19764.37 lbs. Compression in N $n$ and E $e$.

Next value of $u' - \frac{p}{2} = 25$,

39768.75 lbs. Tension in $n$ P and $e$ C.
29646.56 lbs. Compression in P $p$ and C $c$.

In panel $p$ R $r$,

$u' - \frac{p}{2} = 0$, $\therefore$ V = 37500

37500 × 1.414 = 53025 lbs.
Tension in $p$ R and $c$ A.

37500 lbs. is the vertical compression from this simple truss upon the end posts A $a$ and R $r$, which added to the strain from the other simple truss, 35156.25 lbs., gives 72656.25 lbs. as the compression upon the end posts from the weight of the compound truss.

It will be remembered that the vertical strains, in the above cases, affecting the members to the left of the centre, have the minus sign, as $u$ and $u'$ have been measured from the right abutment.

Let the load be brought on at the left abutment, $\frac{w'(l-u)^2}{2l^2}$ is the weight passing to the right abutment, $u$ being the distance of the end of the load from the right abutment, and $l-u$, consequently, is the portion of the truss which is loaded. The values of $u$ are confined to the centres of the panels of the compound truss.

It will be seen from the plan of the truss, Fig. 14, that the passing load, before reaching the centre, transmits that portion of its weight which is borne by the right abutment, through the counterbraces, from one of the simple trusses to the other.

As shown before, the point where counterbracing becomes necessary, is where the portion of the passing load, $\frac{w'(l-u)^2}{2l^2}$, before it reaches the centre that goes to the farther abutment, is equal to the vertical strain of the constant load $\left(\frac{w}{2} - \frac{w\,u}{l}\right)$ that passes to the other nearer abutment; but in this case the vertical strain of the constant load is divided into equal separate parts, while the passing load is not divided; counterbracing will therefore become necessary when

$$\frac{w'(l-u)^2}{2l^2} = \frac{w}{4} - \frac{w\,u}{2l},$$

for then the load borne by the right abutment begins to be greater than the strain to the left abutment from the constant load of either of the simple trusses, and the difference must be transmitted by a counterbrace to the other simple truss.

$a$, therefore, becomes equal to 4 in equation (26).

$$l-u = \frac{l}{a} - l\sqrt{\frac{1}{a} + \frac{1}{a^2}} - l = 200.$$

Whence $l-u$ = 61.80.

or counterbracing will become necessary at 61.8 feet from the abutment. This will be within the load on five panels. Making $l-u = 62.5$ and substituting the values of the constants in $\frac{w'(l-u)^2}{2l^2}$ we obtain 14648.44 lbs., the part of the load which passes to the right abutment; but in panel $f$ F $h$ this strain meets 9375 lbs. passing to the left abutment, leaving 14648—9375 = 5273.44 lbs. for the vertical strain on $f$ G, the first counterbrace.

5273.44 × 1.414 (secant of the angle of the counterbrace) = 7456.64 lbs., longitudinal tension in the counterbrace $f$ G and the corresponding one L $m$.

Bringing the load on to the centre of the next panel,

$l-u = 75$, V = 21093 75 lbs.,

vertical strain to the right abutment, meets 9375 lbs. in panel $g$ G $i$ passing to the left, and $21093.75 - 9375 = 11718.75$ lbs. the vertical strain in $g$ H and $h$ H, and the corresponding braces on the other side of the centre, $l$ $k$ and K $k$. These four braces by the peculiar construction of the truss can never act except as counterbraces.

$11718.75 \times 1.414 - 16570.31$ lbs.
Tension in $g$ H and $l$ K.

Advancing to the centre of the next panel,

$l - u = 87.5$, and V $= 28710.94$ lbs.

In the panel $h$ H $j$ there is no vertical strain from the weight of the bridge, consequently

$28710.94 \times 1.414 = 40597.27$ lbs.
Tension in $h$ I and $k$ I.
$28710.94 \times 1.0541 = 30264.2$ lbs.
Compression in I $i$ or I $j$.

This strain may pass through either of these struts, or may be divided evenly or unevenly between the two. Each therefore must be proportioned to bear the whole strain.

Advancing another panel,

$l - u = 100$, and V $= 37500$ lbs.

There is no vertical strain from the bridge at this point.

$37500 \times 1.414 = 53025$ lbs.
Tension in $i$ K and $j$ H.

This is supposing all the strain to pass down the strut I $i$, but with the exception of the load upon $i$, it may pass down the strut I $j$.

$37500 \times 1.0541 = 39528.75$ lbs.
Compression in $k$ K and H $h$.

Advancing another panel,

$l - u = 112.5$, V $= 47460.94$ lbs.

The whole of this except the load upon $i$ (18750 lbs.) may pass through the tie $j$ L.

$(47460.94 - 18750) \times 1.414 = 40597.27$ lbs.
Tension it $j$ L from the passing load;

to which must be added the tension from the weight of the truss, 13256.25 lbs., and we have 53853.52 lbs. for the greatest tension to which $j$ L and the corresponding tie $i$ G are subject.

In like manner,

$(28710.94 \times 1.0541) + 9882.19 = 40146$ lbs.
Compression in L $l$ and G $g$.

Advancing another panel,

$l - u = 125$, V $= 58593.75$ lbs.

All of which except the load upon $j$, 18750 lbs., may pass through $k$ M; deducting this and adding truss strain,

$(58593.75 - 18750) \times 1.414 + 13256.25 = 69595.35$ lbs.
Tension in $k$ M and $h$ F.
$(58593\ 75 - 18750) \times 1.0541 + 9882.19 = 51881.48$ lbs.
Compression in M $m$ and F $f$.

Advancing another panel,

$l - u = 137.5$, V $= 70898.44$ lbs.

From which deduct the two panel loads on $i$ and $k$ (37500 lbs.), and add the truss strains as before.

$(70898.44 - 37500) \times 1.414 + 26512.5 = 73737.89$ lbs.
Tension in $l$ N and $g$ E.
$(70898.44 - 37500) \times 1.0541 + 19764.37 = 54968.66$ lbs.
Compression in N $n$ and E $e$.

Advancing another panel,

$l - u = 150$, V $= 84375$ lbs.

From which deduct the panel loads on $j$ and $l$, and add the truss strains as before,

$(84375 - 37500) \times 1.414 + 26512.5 = 92793.75$ lbs.
Tension in $m$ O and $f$ D.
$(84375 - 37500) \times 1.0541 + 19764.37 = 69175.3$ lbs.
Compression in O $o$ and D $d$.

Advancing another panel,

$l - u = 162.5$, V $= 99023.44$ lbs.

Of which, only the loads on $j$, $l$, and $n$ $= 56260$ lbs., can affect $n$ P. Multiplying and adding truss strains.

$(56250 \times 1.414) + 39768\ 75 = 119306.25$ lbs.
Tension in $n$ P and $e$ C.
$(56250 \times 1.0541) + 29646.56 = 88949.68$ lbs.
Compression in P $p$ and C $c$.

Advancing another panel,

$l - u = 175$, V $= 114843.75$ lbs.

From which deduct the weight on $j$, $l$ and $n$ $= 56250$ lbs., and add the truss strains.

$(114843\ 75 - 56250) \times 1.414 + 39768\ 75 = 122620.31$ lbs.
Tension in $o$ Q and $d$ B.
$(114843.75 - 56250) \times 1.0541 + 29646.56 = 91410.25$ lbs.
Compression in Q $q$ and B $b$.

Advancing another panel,

$l - u = 187.5$, V $= 131835.94$ lbs.

Of which only the panel loads on $j$, $l$, $n$ and $p = 75000$ lbs., can affect $p$ R. Add truss strains,

$(75000 \times 1.414) + 53052 = 159102$ lbs.
Tension in $p$ R and $c$ A.

Advancing the end of the load to a point midway between $q$ and $r$,

$l - u = 196.875$, V = 145349.12 lbs.

From which deduct panel loads on $j$, $l$, $n$ and $p = 75000$ lbs., and add the truss strains,

$(145349.12 - 75000) \times 1.0541 + 37058.2 =$
111213.2 lbs.
Tension in $q$ R and $b$ A.
145349.12 + 72656.25 = 218005.37 lbs.
Compression in end posts R $r$ and A $a$.

We have now obtained all the strains that can affect the members of the Post Truss, and have given formulæ that can be applied to similar trusses of different dimensions.

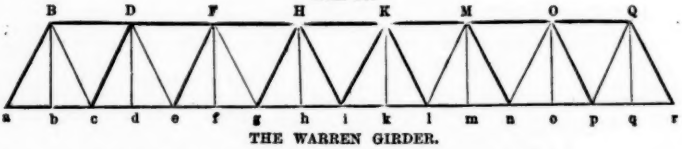
Some marked peculiarities of this truss deserve notice.

The extent of the upper chord affected by the maximum strains.

The unusual amount of counterbracing required, 8 counter-ties and 4 counter-struts being necessary in the example we have given. From these causes the weight of the central portion of this truss is proportionately heavier than the similar part of almost any other truss in general use. More of the load is borne directly by the truss than in the other examples. All these and other peculiarities are disadvantages when compared with other compound trusses. Compared with a Murphy Whipple Truss, the compound structur of the Post Truss, gives it greater lightness, though the difference is comparatively small. Whatever may be the advantages of the claimed economical inclinations of the ties and struts, they are more than balanced by the difficulties arising from these very inclinations in the centre of the system, and the great amount of extra ties and struts or counterbraces, required to properly unite them.

*Example 5th*.*

FIG. 17.




THE WARREN GIRDER.

This is one of the simplest and best forms of truss in use. Equations (11) and (25) apply without change. In the first, $x$ is the horizontal distance from the abutment to the apex either at the upper or lower chord of any of the triangles, and equation (11) gives the horizontal strain in the opposite base, $u$ in equation (25) is the distance to the centre of any inclined brace. A panel includes but one member subject to a strain having a vertical component. The vertical rods merely transfer one panel load to the upper chord.

Let $l = 200$ ft., the length of the truss.
$d = 18.75$ ft., the depth of the truss.
$w = 150.000$ lbs., the weight of the truss.
$w' = 300000$ lbs., the weight of a full uniform load.

Substituting the values of the constants in Eq. (11),

$H = 12000\,x - 60\,x^2$.
For first value of $x$, 12.5, H = 140625 lbs.
Tension in $p$ $q$ and $a$ $c$.
For the next value of $x$, 25, H = 262500 lbs.
Compression in O Q and B D.
For the next value of $x$, 37.5, H = 365625 lbs.
Tension in $n$ $p$ and $c$ $e$
For next value of $x$, 50, H = 45000 lbs.
Compression in M O and D F.
For next value of $x$, 62.5, H = 515625 lbs.
Tension in $l$ $n$ and $e$ $q$.
For next value of $x$, 75, H = 562500 lbs.
Compression in K M and F H.
For next value of $x$, 87.5, H = 590625 lbs.
Tension in $i$ $l$ and $q$ $r$.
For next value of $x$, 100, H = 600000 lbs.
Compression in H K.

In equation (25) substituting the values of the constants,

$V = 75000 - 750\,u + 3\ 75\,(l-u)^2$.
For first value of $u$, 6 25, V = 211084 lbs.
211084 × (1.20185 secant of the brace angle)
= 253691 lbs.
Compression in Q $r$ and $a$ B.
When $u = 18.75$,
221297.8 lbs. Tension in Q $p$ and B $c$.
When $u = 31.25$,
190312.9 lbs. Compression in O $p$ and D $c$.

* From Iron Truss Bridges for Railroads.

When $u = 43.75$,
150735 lbs. Tension in O $n$ and D $e$.
When $u = 56.25$,
132567 lbs. Compression in M $n$ and F $e$.
When $u = 68.75$,
105807 lbs. Tension in M $l$ and F $g$.
When $u = 81.25$,
80455 lbs. Compression in K $l$ and H $g$.
When $u = 93\ 75$,
56513 lbs. Tension in K $i$ and H $i$.
When $u = 106.25$,
33979 lbs. Compression in H $i$ and K $i$.
When $u = 118.75$,
12853 lbs. Tension in H $g$ and K $l$.
When $u = 131.25$,
$-5713$ lbs. Tension in F $g$ and M $l$.

The same kind of strain these braces were subject to when the load covered the centre.

It will be remembered that equation (25) gives the weight on the abutment from which $u$ is measured, when the result has the plus sign; and the character of the strain is determined by the inclination of the braces. K $l$, H $g$, K $i$ and H $i$ are the only braces subject to both tension and compression, or which act as counterbraces. All the others being subject to only one kind of strain.

The Warren Girder affords an illustration of the subject of counterbracing superior to any other form of truss, because the main braces act as counterbraces, and the strains passing in opposite directions neutralize each other in the same brace. In Col. Merrill's Triangular Truss, page 93, the braces of cast-iron are made hollow, with wrought iron ties passing through their cavities. Using his results, the figure being the same as that given above, and beginning with B C, his first double brace, the tension from the truss weight is 73125 lbs. The greatest compression on this brace is 1,322 lbs. from the passing load. Suppose now, ininstead of having a double brace, we have one that can act only as a tie. The result will undoubtedly be, not that this tie suffers compression, for compression and tension cannot exist in the same member at the same time, but that the strain in this tie is the difference between the amounts of compression and tension to which it is subject, or 73125 – 1322. This being the greatest compression in this tie, and the tension in like manner being the least, and constant, it certainly is very evident that this brace can never act otherwise than as a tie.

In the same manner, from the same author's calculations, D $c$'s minimum and constant compression is 61875 lbs., aad its maximum tension is 3966.1 lbs., or it cannot act otherwise than as a strut.

D $e$'s minimum and constant tension is 50,625 lbs., its maximum compression 13,360 lbs., or it is always a tie.

F $e$'s minimum and constant compression is 39,375 lbs., its maximum tension 12,896 lbs., or always a strut.

F $g$'s minimum and constant tension 28,125 lbs., its maximum compression 28,303 lbs.

The difference, 178 lbs., is all the compression this tie can be subject to, and this is the first brace that can act as a counterbrace.

H $g$'s minimum and constant compression is 16,875 lbs., maximum tension 26,003 lbs., the difference 9,128 lbs., is all the tension this brace can be subject to.

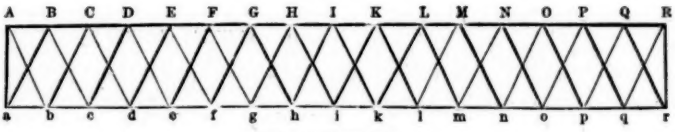
The last brace H $i$ has a minimum and constant tension of 5,625 lbs., and a maximum compression of 46,448 lbs., the difference, 40,823 lbs., is all the compression this brace can be subject to.

From which we see that F $g$, H $g$ and H $i$ only can act as counterbraces.

*Example 6th.*

Let Fig. 18 represent a Lattice Truss, consisting of two systems of triangles, with the load traversing the lower chord.

FIG. 18.




THE LATTICE TRUSS.

This, like the Post and Whipple Trusses, is a double truss, and is composed of two Warren Trusses whose vertical strains are entirely independent of each other.

Separating them for a more easy con-

sideration of their strains, we have one truss, Fig. 19, bearing one half the load, and another truss of the form in Fig. 20, bearing the other half of the load.

FIG. 19.

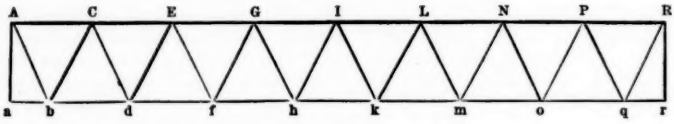
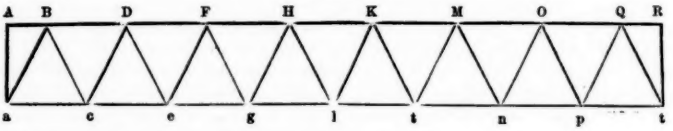



FIG. 20.




In Fig. 19, no weight rests directly on the abutment.

In Fig. 20, a half panel load must be considered as being borne directly by each abutment.

Let $l = 200$ ft., the length of the truss.
$d = 18.75$ lbs., the depth of the truss.
$w = 150000$ lbs., the weight of the truss.
$w' = 300000$ lbs., the weight of a full uniform load.
$x$ = distance of any apex in the compound truss from the abutment.
$u$ = distance midway between two loaded apices of either single truss from the abutment.
$p = 12.5$ ft., the distance between the apices of the compound truss or the length of a panel.

In Fig. 19, $x$ being the distance of any apex in the upper chord from the abutment, equation (11)

$$H = \frac{(w' + w)x}{4d} - \frac{(w' + w)x^2}{4dl}$$

is the horizontal strain in the lower chord opposite that apex, $\frac{w' + w}{2}$ being the portion of the weight borne by that truss.

$x'$ being the distance from the abutment to any apex in the lower chord.

$$H = \frac{(w' + w)x'}{4d} - \frac{(w' + w)}{2dl}(x' - p)\frac{(x' + p)}{2}$$
$$= \frac{(w' + w)x'}{4d} - \frac{(w' + w)x'^2}{4dl} + \frac{(w' + w)p^2}{4dl} \quad (41)$$

will be the horizontal strain in the upper chord, opposite that apex.

In Fig. 20, $x$ being the distance from the abutment of any apex in the upper chord, and $\frac{w' + w}{2}$ being the load borne by this truss.

$$H = \frac{(w' + w)x''}{4d} - \frac{(w' + w)px''}{2dl} -$$
$$\frac{(w' + w)}{2dl}(x''' - p), \left(\frac{x'' - p}{2}\right), = \frac{(w' + w)x''}{4d} -$$
$$\frac{(w' + w)x''^2}{4dl} - \frac{(w' + w)p^2}{4dl} \quad (42)$$

in the horizontal strain in the lower chord opposite that apex, and $x'''$ being the distance from the abutment of any apex in the lower chord,

$$H = \frac{(w' + w)x'''}{4d} - \frac{(w' + w)x'''^2}{4dl} \quad (43)$$

is the horizontal strain in the upper chord opposite that apex.

The value of H in one simple truss at $x'$ added to the value of H in the other simple truss at $x' + p$ will give the amount of the horizontal strain in the upper chord of the double truss between $x'$ and $x' + p$; and in the same way the value of H at $x$ in one simple truss added to the value of H at $x - p$ will give the horizontal strain in the lower chord between $x$ and $x - p$.

Adding upper chord equations (41) and (43) and making $x''' = x' + p$. (If $x'$ be made equal to $x''' + p$ the result will be the same.)

$$H = \frac{(w' + w)x'}{2d} + \frac{(w' + w)p}{4d} - \frac{(w' + w)x'^2}{2dl} -$$
$$\frac{(w' + w)x'p}{2dl} - \frac{(w' + w)x'p^2}{8dl} + \frac{(w' + w)p^2}{8dl} =$$
$$\frac{(w' + w)}{2d}\left(x' + \frac{p}{2}\right) - \frac{(w' + w}{2dl}\left(x' + \frac{p}{2}\right)^2 + \frac{(w' + w)p^2}{8dl} \quad (44)$$

Substituting the values of the constants,

$$H = 12000\left(x' + \frac{p}{2}\right) - 60\left(x' + \frac{p}{2}\right)^2 + 2343.75$$

$x' + \frac{p}{2}$ being the distance to the centre of any panel.

When $x' + \frac{p}{2} = 6.25$, H = 75000 lbs.
Compression in Q R and A B.

When $x' + \frac{p}{2} = 18.75$, H = 206250 lb.
Compression in P Q and B C.

When $x' + \frac{p}{2} = 31.25$, H = 318750 lbs.
Compression in O P and C D.

When $x' + \frac{p}{2} = 43.75$, H = 412500 lbs.
Compression in N O and D E.

When $x' + \frac{p}{2} = 56.25$, H = 487500 lbs.
Compression in M N and E F.

When $x' + \frac{p}{2} = 68.75$, H = 543750 lbs.
Compression in L M and F G.

When $x' + \frac{p}{2} = 81.25$, H = 581250 lbs.
Compression in K L and G H.

When $x' + \frac{p}{2} = 93.75$, H = 600000 lbs.
Compression in I K and H I.

Adding lower chord equations (11) and (42) and making $x'' - p = x$. (If $x''$ be made equal to $x - p$ the result will be the same.)

$$H = \frac{(w'+w)c}{2d} - \frac{(w'+w)c^2}{2d} - \frac{w'+w)p}{4d} + \frac{(w'+w)px}{2dl} - \frac{(w'+w)p^2}{2d} = \frac{(w'+w)}{2dl}\left(x - \frac{p}{2}\right) - \frac{(w'+w)}{2dl}\left(x - \frac{p}{2}\right)^2 - \frac{3(w'+w)p^2}{8dl} \quad (45)$$

Substituting the values of the constants,

$$H = 12000\left(x - \frac{p}{2}\right) - 60\left(x - \frac{p}{2}\right)^2 - 7031.25$$

When $x - \frac{p}{2} = 6.25$, H = 65625 lbs.
Tension in $q$ $r$ and $a$ $b$.

When $x - \frac{p}{2} = 18.75$, H = 196875 lbs.
Tension in $p$ $q$ and $b$ $c$.

When $x - \frac{p}{2} = 31.25$, H = 309375 lbs.
Tension in $o$ $p$ and $c$ $d$.

When $x - \frac{p}{2} = 43.75$, H = 403125 lbs.
Tension in $n$ $o$ and $d$ $e$.

When $x - \frac{p}{2} = 56.25$, H = 478125 lbs.
Tension in $m$ $n$ and $e$ $f$.

When $x - \frac{p}{2} = 68.75$, H = 534375 lbs.
Tension in $l$ $m$ and $f$ $g$.

When $x - \frac{p}{2} = 81.25$, H = 571875 lbs.
Tension in $k$ $l$ and $g$ $h$.

When $x - \frac{p}{2} = 93.75$, H = 590615 lbs.
Tension in $i$ $k$ and $h$ $i$.

To ascertain the vertical strains, equation (25) is applicable to both simple trusses. It will avoid confusion to calculate the vertical strains of the simple trusses separately.

$$V = \frac{w}{4} - \frac{w\,u}{2\,l} + \frac{w'(l-u)^2}{4\,l^2}.$$

Substituting the values of the constants,

$V = 37500 - 375u + 1.875\,(l-u)^2$ for either simple truss.

Since simple truss, Fig. 19, has the centre of the end panel at the end of the truss, the first value of V is, when $u = 0$,

V = 112500 lbs., compression in end posts $R$ $r$ and $A$ $a$.
112500 × 1.20185 (secant of brace angle) = 135208 lbs., tension in R $q$ and A $b$.
When $u = 25$, V × 1.20185 = 102815 lbs.
Compression in P $q$ and C $b$.
Tension in P $o$ and C $d$.
When $u = 50$, V × 1.20185 = 73238 lbs.
Compression in N $o$ and E $d$.
Tension in N $m$ and E $f$.
When $u = 75$, V × 1.20185 = 46478 lbs.
Compression in L $m$ and G $f$.
Tension in L $k$ and G $h$.
When $u = 100$, V × 1.20185 = 22535 lbs.
Compression in I $k$ and
Tension in I $h$ when the left half of the truss is loaded, when the right half is loaded, there is the same compression in I $h$ and tension in I $k$.
When $u = 125$, V × 1.20185 = 1409 lbs.
Compression in $G$ $h$ and $L$ $k$.
Tension in $G$ $f$ and $L$ $m$.
When $u$ is greater than 125, V has the minus sign and the braces beyond act only as main braces.

For simple truss Fig. 20, the first value of $u$ is 12.5.

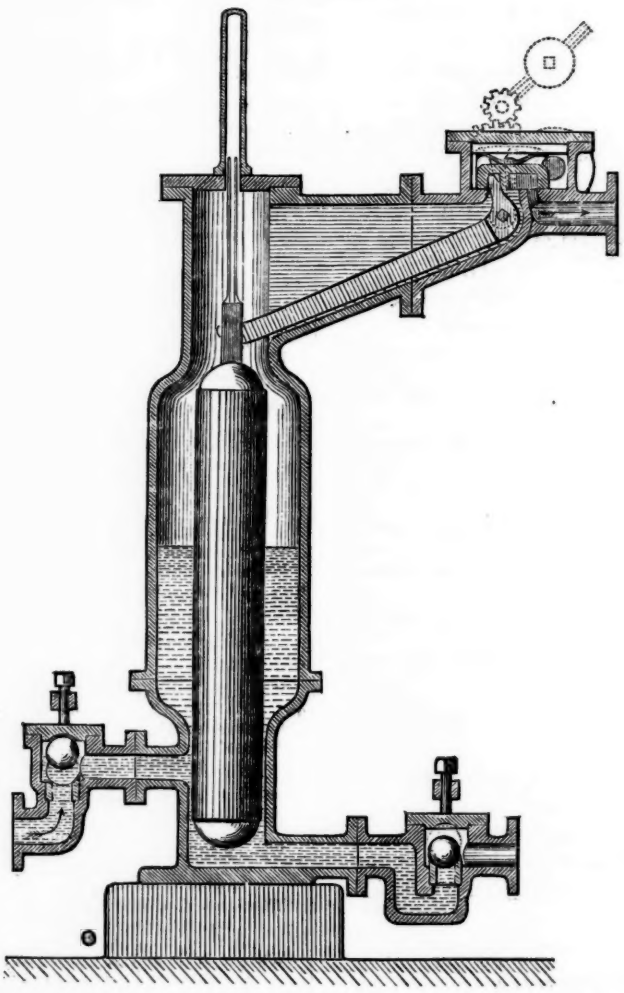
V = 98731 lbs. compression in end posts $R$ $r$ and $A$ $a$, which added to the amount previously obtained gives 211231 lbs. total compression.
98731 × 1.20185 = 118660 lbs.
Compression in Q $r$ and B $a$.
Tension in Q $p$ and B $c$.
When $u = 37.5$, V × 1.20185 = 87674 lbs.
Compression in O $p$ and D $c$.
Tension in O $n$ and D $e$.
When $u = 62.5$, V × 1.20185 = 59506 lbs.
Compression in M $n$ and F $e$.
Tension in M $l$ and F $g$.
When $u = 87.5$, V × 1.20185 = 34155 lbs.
Compression in K $l$ and H $g$.
Tension in K $i$ and H $i$.
When $u = 112.5$, V × 1.20185 = 16429 lbs.
Compression in H $i$ and K $i$.
Tension in H $g$ and K $l$.

When $u$ has a greater value, V indicates a strain affecting the other braces only as main braces.
G $f$, G $h$, I $h$, I $k$, L $k$, L $m$, H $g$, H $i$, K

*i* and K *l* only, act as counterbraces. A lattice truss, made of two or more simple Warren Trusses, properly proportioned and practically arranged, is undoubtedly one of the simplest, lightest, strongest and cheapest trusses in use.

## AUTOMATIC BOILER FEEDER.

From "Revue Industrielle."



This new feeder of Macabies is designed to maintain a constant level in steam boilers. It is composed of a cylindrical receiver furnished with too spherical valves, one slide valve, and a [illegible] water-gauge.

The receiver is put in communication first with the atmosphere and the hot

water of a reservoir, and then with the steam and water of the generator.

It is in reality a supply cylinder of small capacity, working automatically, and having no parts liable to derangement. The work of supplying the boiler is reduced to a simple surveillance of the apparatus.

When the float is down, as in the figure, the steam in the receiver can escape by the valve at the upper right-hand corner, and hot water from the proper reservoir flows in by the valve at the lower left-hand side. As the receiver fills, the float rises and closes the right-hand upper valve; the steam, then acting upon the water of the receiver, closes the valve which admits the supply and opens the valve upon the opposite side, which opens communication with the boiler. The water, being subjected to equal pressure above and below, flows into the boiler by virtue of its weight. The float descending with the water shuts the steam valve and the water again flows in.

This movement of the float continues until the end of the pipe supplying steam is covered by the water. The feeder then ceases to work, but resumes its action as soon as the steam is again free to act upon the water of the receiver.

The slide valve is worked by a bent lever, as shown in the figure; the axis of this lever is extended, and has fitted to it, on the exterior of the apparatus, a double sector, which serves to operate as a counterpoise. The object of this latter is to correct the too gradual movement of the float; it is so adjusted that the float does not commence its motion either up or down until the liquid surface has moved through considerable space; it then makes a complete stroke with an accelerating velocity.

In the smaller varieties of this instrument, a second counterpoise attached to the first sector is found to be necessary.

The pipe which conducts steam to the receiver terminates in a perforated cover, so as to avoid irregularities arising from too great disturbance of the water in the generator.

Compared with a feed-pump, this apparatus of Macabies presents some advantages. 1st. It works without aid of the engine, or special steam cylinder. 2d. It economizes 4 or 5 per cent. of the fuel. 3d. It cannot produce shocks to impair the working of the engine.

Compared with the Giffard injector, which also works without aid of the engine, it has the disadvantage of being less accessible to the fireman and also of having parts in motion during the filling; but, on the other hand, it can work with the water at 100 deg. Centigrade, and it operates without interruption, which compensates for the disadvantages enumerated.

In small boilers especially, supplied by the Giffard injector working at intervals, the pressure varies considerably, and the injector becomes uncertain in its action. With a difference of 70 deg. temperature between boiler and feed water, the Macabies feeder is much more efficient than Giffard's. Finally the employment of water at a high temperature will save the boiler largely from incrustations.

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Colors of Gases in Geissler Tubes Changed by Magnetism.—M. Trève, in a late communication to the French Academy of Sciences, gives an account of his experiments with gases inclosed in glass tubes and exposed to a current of electricity, and at the same time to the influence of a powerful electro-magnet. Having taken a Geissler tube filled with hydrogen, one portion of the tube being drawn out to capillary thinness, he caused the induction current to pass through it, which, as is well-known, imparts to the gas in the thick part a blue color, tinged with violet, and in the capillary portion a brilliant red. Now if the latter be placed between the poles of the electro-magnet, the red at once disappears, and is converted into white light. In the case of oxygen, the capillary part is milky white; under the influence of electro-magnetism it becomes red. Under the same circumstances the blue of nitrogen becomes much darker, and the sparkling white of carbonic acid turns blue. Hence, so far, magnetism is found to destroy or change the color of a gas in the capillary part of a tube containing it.

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The St. Louis "Review" says: Messrs. Bidwell & Blake, of the American Plate Glass Works, have arrived in New York from Europe, and are expected in St. Louis in a week to inaugurate the erection of their extensive works near this city.

## PURIFICATION OF SEWAGE.

From "The Engineer."

It occasionally happens that the soundest theory will not work out in practice; but it is delusive to imagine that a theory that is radically unsound will ever work out at all. Yet, there are people whom it is impossible to persuade of this fact, and nothing less than trial after trial, and experiment after experiment, will convince them of their error. Repeated failures of the most tangible and palpable nature are scarcely sufficient to open their eyes, and even when the results are incontestably erroneous, they remain in the position of men convinced against their will. So long as it is possible to cast the shadow of a doubt upon the evidence that weighs against them, or the allegations that may be put forward by their opponents, they uphold their opinion, and cling with the tenacity of fanaticism to the object of their idolatry. But as, notwithstanding the superstition of the devotees, all false beliefs must terminate eventually for lack of converts, so the votaries of a theory that is untenable, and a practice that is fallacious, will ultimately fail to enrol among their members those who are true believers. It is probable that some of the latter may be led away for a time by specious arguments, distorted facts, and apparent realities; but in this age of rigid inquiry and investigation the inevitable exposure comes sooner or later. Those who once almost believed in the integrity of their scientific creed, subsequently blush for their credulity, and endeavor by the strength of their recantation to atone for their apostacy. Thus, in the end, the cause of truth prevails, and at whatever cost that object may be attained no one will repine at it but those who endeavored to prevent it. If these were the only people upon whom the cost was to fall it would be but a just retribution for their attempts to disseminate error; but, unfortunately, the innocent are mingled with the guilty, and rates press heavily upon both.

It is now some years since we first ventilated in our columns the great national question of the day, and from that time to this we have advocated, with unflinching fidelity, the principle of sewage irrigation. There was then but very little encouragement to do so. The principle was altogether untried, if we except such instances as those which occur at Edinburgh. It was on its probation at Croydon, where it was not then the great success it is now, and many who participated in our views, theoretically regarded, were not bold enough to assert their belief in their practical application. Moreover, there was a host of hostile patentees and inventors of sewage nostrums in the field, who, while lauding to the skies the infallibility of their own individual panaceas, forgot their private differences, and made common cause against their common foe—the advocates of sewage irrigation. Another difficulty the latter had to contend against was, the comparatively circuitous course they were compelled to adopt in order to obtain a chance of demonstrating the correctness of their opinions. The first stumbling-block in their way was the necessity of procuring land for their purpose, which was a tedious and expensive, and sometimes an impossible affair. On the other hand, a few settling tanks and some mechanical and chemical appliances sufficed to put in working order the disinfecting and purifying apparatus. The relative cost, too, was all in favor of the nostrum party, and, moreover, they offered the alternative of abandonment on failure—an event which has happened pretty frequently—whereas, when land has been purchased and the necessary works constructed for irrigating it with sewage, the abandonment of the whole project is a thing not to be contemplated. Some of the favor which has been accorded by local boards to the various deodorizing and disinfecting processes is undoubtedly due to the fact of their being capable of merely temporary use, as they are readily erected, and, as reference has shown, more readily pulled down. Being convinced, after a careful examination, that the principle of sewage irrigation was they only one that offered a solution of the two great problems in connection with this momentous question, it remained for us to watch vigilantly for the results of actual practice.

The two great problems offered for solution are the purification of the sewage

so as to render the effluent or supernatant water sufficiently clear and unpolluted to pass into the nearest natural watercourse without contaminating it; and the manufacture of a salable manure. The success which has attended the adoption of the irrigation system at Croydon, Norwood and elsewhere, has fully and conclusively demonstrated that both these operations are perfectly effected through its instrumentality. Repeated analyses of the contents of those streams which are situated in close proximity to the outfall of the effluent water have shown them to be quite free from any sewage pollution, and that, in addition, the quantity of solid matter due to the discharge rarely exceeds two grains in the gallon. The manufacture of a salable manure from the residue in the reservoirs and settling tanks is comparatively of no importance, as the land is fertilized by the flowing of the liquid over it. Can it be said that a single one of the numerous so-called purifying processes has succeeded in securing either of these desiderata? After a perusal of the second report of the Rivers Pollution Commission it is unnecessary to ask the question.

Accepting the fact—which is too notorious to be contradicted—that all our rivers and streams are merely running sewers, it is only natural that preventive processes should have engaged the attention of, at any rate, chemists. We doubt whether the preparation of anti-sewage medicines can be strictly regarded as a legitimate professional occupation. The Commissioners, in their first report, reviewed the principal methods of treating sewage for the purpose of defecation and purification, and those who have perused it, will be aware that the lime process, and that termed the "A. B. C." process, were the two that were least objectionable of all those included in the common category. Both of these partially fulfilled the intended design, but the result in both instances fell very far short of what was not only desirable, but, on sanitary grounds, indispensable. The effluent water was not rendered sufficiently pure to be permitted to flow into a stream, and the manure manufactured was practically of little or no value. Since the issue of the report, the "A. B. C." process has been very prominently and very confidently advocated by the promoters, and has altogether superseded the lime process. This last may be, therefore, dismissed from consideration, and our attention concentrated on the other, more especially as a close and impartial investigation into its whole theory, *modus operandi*, and practical results, forms the subject of the second report of the Commissioners. To any one but the promoters of the scheme themselves this second inquiry would be totally unnecessary; but as they raised some objections to the first experiments, conducted at Leicester and Leamington, the Commissioners consented to give them another trial, although they had themselves a tolerably accurate anticipation of what would be the only conclusion they would arrive at. The objections to the first ordeal raised by the "A. B. C." gentlemen were that the results of the experiments were inconclusive, insomuch as accident had interfered with them at Leicester, and that at Leamington the weather had been wet and unfavorable. One is ready, on receiving a reliable explanation, to admit the validity of the first excuse, but by no means that of the second. If a process for effecting the disinfection and purification of sewage cannot be carried on in wet, or any other kind of weather, the sooner it is done away with the better. This would be a sufficient cause, in our opinion, to reject the whole project at once. It is in wet weather that the evil is greatest, and the remedy should be the most active. The Comm ssioners state plainly their own convictions that the objections of the promoters were futile, and that the circumstances complained of were not calculated in any manner to vitiate the experiments referred to. While we applaud the manifest candor and sense of justice and fair play displayed by those gentlemen in the execution of a public duty, we are not convinced that any necessity existed for incurring the expense of a second set of experiments, an opinion fully confirmed by the contents of the report. On the whole, it is perhaps just as well that the second trial has taken place, for it is conclusive, will set at rest for ever all doubts on the matter, and adds one more corroboration to the truth of the irrigation principle so strongly upheld by all our most eminent engineers.

It will be universally admitted that the purification, or the clarification, of the effluent water of sewage, is more impor-

tant to the sanitary welfare of the community than the production of an artificial manure from the solid residue; consequently the former must always be the first consideration, and any process that does not accomplish this is valueless, notwithstanding whatever might be the quality of the manufactured manure. The standard determined by the Commissioners with respect to admitting effluent sewage water into rivers is, "that any liquid containing in suspension more than one part by weight of dry organic matter in 100,000 parts by weight of the liquid" is not admissible. But the "A. B. C." process is not competent to reach this standard, as the average of the analyses of the samples taken on three consecutive days gave 2.82 parts of suspended organic matter in 100,000, or nearly three times the amount allowed. In every instance there is always left in solution a balance of solid matters, which is greater than the amount originally present in the sewage. It certainly strikes the observer as a somewhat paradoxical circumstance, to attempt to purify sewage by adding to it a large quantity of extraneous substances. The amount of the suspended organic matter is not of so much importance in the effluent water as the quantity of organic nitrogen, since it is the latter which, by reason of its highly putrescible nature, chiefly causes pollution in a stream. Unfortunately the process fails, not only to remove the organic nitrogen, but in fact actually increases the amount of it in solution. It has been stated before in our columns that the purification of the effluent water and the production of an artificial manure from the residue are complementary operations, the successful execution of the one necessitating that of the other. A mere glance at the evidence before us is more than enough to prove how inefficacious and crude is the "A. B. C." process. An inspection of the analytical tables demonstrates that the amount of total combined nitrogen, which very nearly represents the manure value, is greater in the effluent water than in the residue, thus in reality causing the former, which is intended shall flow away and be lost, to be a better manure than the raw sewage. The Commissioners remark, "this fact is very significant, as bearing upon the manufacture of manure by the 'A. B. C.' process, when it is remembered that seven-eighths of the manure value of sewage reside in the soluble constituents." After this no one will be surprised to learn that the artifically prepared manure, which is theoretically, or rather chemically, valued at 17s. per ton, barely realizes one. The remark is full of truth, that "without fortification with sulphate of ammonia, nitrate of soda, or superphosphate of lime, such manures are scarcely soluble."

The experiments at Leamington were, so far as the conclusions to be arrived at, a corroboration of those already come to after witnessing the previous one at Leicester. The effluent water was more impure than at the former place, and the yards around the buildings were covered with sewage mud spread out to dry. "The smell was extremely offensive, and the process would be pronounced a nuisance whenever conducted in or near a town." In addition, the filters were choked up, and masses of dark putrid mud, buoyed up by gas, occasionally rose to the surface and floated into the river. Altogether, to judge from the description in the report, the whole process at Leamington must be sufficiently disgusting, and the result is, "but a very slight purification of the sewage of that town." The effluent water discharged into the river Leam contained almost exactly as much soluble polluting matter as the raw sewage, although it had been treated with a proportion of the "A. B. C." mixture one-eighth greater than that presented by the specification. On some occasions, as much as double the specified quantity has been employed. The Commissioners' final remark, respecting the pretended purification by this system is, "On no occasion, even when mixed with more than four times its volume of clean river water, was the effluent sewage other than a polluting liquid, offensive to the senses even at the moment of discharge, and always quite unfit to be admitted into running water." Were any more tangible proof required to demonstrate that the attempted purification is a mere farce, it is to be found in the comparison of the state of the river above and below the outfall of the "A. B. C." works. Above the outfall the river was somewhat turbid, but on the whole presenting the appearance of an unpolluted stream. There were no *fungi* nor any indications of putrescence to be observed. Below, masses of putrid mud were drifting about

the surface; sewer *fungi* were growing abundantly on submerged objects near the bank, increasing notably in quantity as they approached the outfall. The artificially prepared manure is said to sell for £3 10s. per ton, but the evidence to support this statement may be well described to be "of the weakest kind." If this sum is given for it by the farmers they must be a most confiding race of bucolics, or guano must command a fabulous price in those parts. The "report" sums up by observing: "As, therefore, the inevitable conclusion is unfavorable to the 'A. B. C.' process in respect of its alleged power to hinder the pollution of rivers by town sewage, so also is it altogether unfavorable to the value of the manure which it manufactures."

The most strenuous and uncompromising adherents of all these patent anti-sewage panaceas must confess that they have one and all had a perfectly fair trial, and that they have all failed miserably to effect what they so pretentiously asserted they could accomplish. There is scarcely one of these quack methods which some unfortunate local board or other has not been seduced into experimenting upon, and all with the same result. We hope they can reconcile it to the ratepayers—and their own consciences. One by one they are renouncing them in favor of irrigation, and they have paid dearly enough for their experience. We have always advocated a fair trial for everything that will bear a sound investigation into its merits, even although our anticipations might tend to the conclusion that in practice it might be "found wanting;" but we trust that we shall hear of no more trials. It is time these delusions were terminated. A witness of high professional standing and unblemished integrity gave before the Commission his opinion of the "A. B. C." process. He said: "As regards its superior defecation of sewage, and the high value of the product yielded, I came to the conclusion that it was simply a juggle." The opinion is forcible, but the evidence, in the mind of any unbiassed person, tends more to prove than to disprove it. Land is the only defecator of sewage, and the sooner that truth becomes recognized the sooner will the report before us be acted upon. The Commissioners state: "We have therefore no hesitation in recommending irrigation as the only plan of dealing with the sewage difficulty at present known to us, which abates a nuisance and turns to profitable account an otherwise valueless material."

## ON WIND FORCE.

From "The Mechanics' Magazine."

The quarterly weather report of the Meteorological Committee, which was noticed in the "Mechanics Magazine" for July 29, revives a discussion on the methods of arriving at the pressure or velocity of wind, which Admiral Fitzroy opened in the third number of "Meteorological Papers," published by the Board of Trade in 1858. The difficulties of the subject were then pointed out, and we are yet no nearer removing them. Let us hope that now it has attracted the attention of the scientific committee, a better status of certainty and uniformity of observation may be attained as regards the wind.

The anemographs erected at the several observatories are, we believe, perfectly similar instruments, identical in all respects, except as to the positions of exposure; but the anemogram plates show that the velocities registered at the three inland stations, Kew, Stonyhurst, and Armagh, fall very far short of those noticed at the coast observatories. Stonyhurst is 361 ft. above the sea, Armagh 207 ft.; nevertheless the inference is that the undulations of the land diminish even at considerable elevations the strength of wind by frictional resistance. The Meteorological Committee have erected an anemograph at the Sailors' Home, Yarmouth, on the beach. Eastward is the sea, westward the ground slopes slowly upward for about a quarter of a mile and then stretches away many miles as a perfectly flat plain. There is it is found that the velocity registered in westerly winds is about one-half of that registered in easterly winds, although the estimated force of wind at the St. Nicholas Gat lightship, at a distance of only two miles at sea, is equal for the two opposite points.

Since 1858 the Admiralty have enforced the usage of the following system of numbers for marking the strength of wind, as proposed by Sir F. Beaufort :—

0. Calm.
1. Light air, or just sufficient to give steerage way.

| | | |
|---|---|---|
| 2 Light breeze | or that in which a well-conditioned man-of-war, with all sail set and clean full, would go in smooth water from | 1 to 2 knots. |
| 3. Gentle breeze | | 3 to 4 knots. |
| 4. Moderate breeze | | 5 to 6 knots. |
| 5. Fresh breeze | or that to which she could just carry in chase full and by | Royals, etc. |
| 6. Strong breeze | | Single-reefed topsails and topgallant sails. |
| 7. Moderate gale | | Double-reefed topsails, jibs, etc. |
| 8. Fresh gale | | Tripie-reefed topsails, etc. |
| 9. Strong gale | | Close-reefed topsails and courses. |

10. Whole gale, or that with which she could scarcely bear close-reefed maintopsail and reefed foresail.
11. Storm, or that which would reduce her to storm-staysails.
12. Hurricane, or that which no canvas could withstand.

However convenient this system may be for the abbreviation of nautical phraseology, it has the defect of not rising by equal units of velocity or pressure. Its general use in the Navy, its extensive use in the merchant service, and its gradual extension among observers on shore, render it desirable to insist upon the recognition of this defect. For the tendency is to overlook the fact that the grades of force progressively increase, and it has become the practice to use the figures so representing forces of wind for the purpose of determining the average wind force, by simply taking the arithmetical average irrespective of the different values of the grades. According to Sir W. Snow Harris winds similarly defined or designated have respectively, in round numbers, velocities of 3, 6, 10, 14, 17, 19, 21, 29, 48, 76, 90, and 114 miles per hour ; or pressures of 0.04, 0.14, 0.5, 0.9, 1.4, 1.7, 2.1, 3.7, 10.4, 26, 36, 57 lbs per. square foot.

Now to show the difficulty of dealing with estimates of wind statistically, let us suppose two notations of force, 4 and 10 ; these are velocities 14 and 76, or pressures 0.9 and 26 ; the averages are 7, 45, and 13.5 respectively, but the velocity corresponding to 7 is only 21 instead of 45, and the pressure 2.1, not 13.5. Before averages can be struck, therefore, the figures of the Beaufort scale should be converted into velocities, otherwise incongruity will result. Here, however, is precisely the difficulty. It is not admitted that Harris's equivalent velocities are sufficiently precise ; and it still remains to establish such a conversion table. From comparisons made between estimated force of wind and velocity recorded by anemograph at Holyhead Lighthouse the mean of 66 observations gives 36 miles an hour for force 6, and the mean of 55 observations gives 43.5 miles an hour for force 7, which are just about double the velocities assigned for the same winds by Harris. With reference to anemographical registration of wind, the various modes of estimating its force, strength, or pressure, require extensive investigation.

Since 1840 Mr. Glaisher, and the observers who act with him, have steadily employed the "land scale," so called, which considers the strength of wind by estimation to be reduced to pressures on the square foot, as follows :—

| | | | | |
|---|---|---|---|---|
| 0.25 | by estimation, is | 1 oz. | pressure | on the sq. ft. |
| 0.5 | " | 4 oz. | " | " |
| 0.75 | " | 9 oz. | " | " |
| 1.0 | " | 1 lb. | " | " |
| 1.5 | " | 2¼ lbs. | " | " |
| 2.0 | " | 4 lbs. | " | " |
| 2.5 | " | 6¼ lbs. | " | " |
| 3.0 | " | 9 lbs. | " | " |
| 3.5 | " | 12¼ lbs. | " | " |
| 4.0 | " | 16 lbs. | " | " |
| 4.5 | " | 20¼ lbs. | " | " |
| 5.0 | " | 25 lbs. | " | " |
| 6.0 | " | 36 lbs. | " | " |

The formula is—
(Estimated force)$^2$ = pressure in lbs. on the sq. ft.

This system, says the "Weather Report," is obviously insufficient, at least in the case of storms; for whereas the highest pressure which is given is 36 lbs., and the corresponding velocity is 85 miles an hour, velocities and pressures respectively exceeding these values have been not unfrequently registered at our own observatories, and also by Mr. Hartnup at the Bidston Observatory. The wind in these islands may be safely asserted scarcely, if ever, to reach the force of 12 Beaufort scale. It can hardly be maintained that storms of the severity of tropical cyclones ever visit our coasts ; if they did, the damage done to buildings and vegetation would be far more serious than it is.

Lind's anemometer, which is intended to measure the force of wind by its effect in raising a column of water in an inverted glass siphon, is read off in inches of difference of level of the water in the two limbs, and the table he gave expresses the pressure as the absolute weight of water so sustained, supposing it to have a base

of a sq. ft. ; thus 6 in. would equal 31.25 lbs., or half a cubic foot of water. But the resistance arising from the deflection of the air, and the difficulty of getting the current to act directly in such an instrument, practically render it useless. It is evident that its indications will be less than the truth. Admiral Fitzroy proposed to convert the land scale into the sea scale by doubling it, but this is evidently fallacious, as can be easily shown by an example: Take 3 by land scale ; this is supposed to be equal to 9 lbs., which by the sea scale is about 9, or three times the land scale. Indeed, there is no relation between the two scales by a constant factor. There is nothing that we can perceive in favor of the land scale, unless it be that the square of the number gives the pressure.

The problem which meteorologists are called upon to solve is the relation between the indications of anemographs and the estimates of wind force, and to furnish a rule for converting one into the other. We are glad to notice that one important investigation will not escape the attention of the Meteorological Committee, which we infer from their statement, that "the periods for which contemporaneous records exist are far too short for us to determine the factor, if any such should exist, by which the velocity at each inland station should be multiplied in order to bring it up to its equivalent at a sea station."

The relation between velocity of wind and its pressure is another subject for experimental research ; at present, authorities agree only to differ in the conversion formulæ which they employ.

## IRON AND STEEL NOTES.

At a late meeting of the Engineers and Shipbuilders' Association, at Glasgow, Scotland, Mr. Wm. Ferrie read a paper "On the Utilization of Blast-Furnace Gases, Coal being used as Fuel." The utilization of gases from blast-furnaces had, the writer said, for many years attracted the attention of ironmasters; and in the Cleveland district, in particular, the consumption of these gases had arrived at a high degree of perfection. In districts where raw coal was the fuel used, nothing could be stated as to the results ; and it had been said that a Scotch furnace sent twice as much unconsumed fuel into the air as was consumed within it. The difficulty in withdrawing the gases from a furnace using raw coal as the fuel was, that the combustion of the gases at the furnace-top was the means whereby the coal was converted into coke, in which state it must be previous to its descent to the zone of reduction. That the gases were in excess of what was required for the coking process was beyond doubt ; but to regulate the withdrawal of them so as not to interfere with the regular workings of the furnace had never been done satisfactorily. Were a practicable plan introduced to admit of the withdrawal of the gases, the saving in fuel would be enormous, and amounting to something like 600,000 tons of coal per annum over the pig-iron furnaces of Scotland. In considering this subject, it occurred to the writer that, if they could coke the coal in furnaces in the same way as coal was coked in the common retorts at gas works, the difficulty would be overcome. He accordingly commenced experiments with a small blast-furnace, about the fifteenth capacity of a 50 ft. furnace. The upper part was divided into two compartments or retorts, into which the coal, ores and flux were charged, and the top was closed in the usual way by the bell and cone. The gases passed off into a main which communicated by two pipes, one to each side of the furnace, to the entrance of the flues at the bottom of the retorts, and were ignited by the aid of atmospheric air. These flues were constructed spirally, in order that the heat from the burning gases might permeate the materials inside of the retorts, while the exhaust gases were thrown off by chimneys at the top of the retorts. This small furnace was worked for about two months with raw coal as fuel only, and the results obtained were highly satisfactory, notwithstanding that the furnace was of so small dimensions. The iron produced was Nos. 1, 3 and 4, and that from materials that had been only 16 hours in the furnace, so great was the rapidity of the "driving" of the furnace. An examination was daily made into the interior of the furnace at the bottom of the retorts, and invariably the coal was found thoroughly coked and at a high heat, the lime completely calcined at the same temperature, and at a like temperature also were the ores. Being convinced that this plan of working a furnace was practicable, operations were immediately commenced for altering one of the ordinary furnaces at the Monkland Ironworks on the same plan, or nearly so. Mr. Ferrie, with the aid of diagrams, described this furnace, and also another modification of a self-acting coke furnace. The throat of this furnace was contracted in diameter, whilst of a proportionally increased vertical length, so as to form a single retort, which was heated by burning gases surrounding it. He proposed to introduce a portion only of the coal, or, it might be, of coke, into the central retort along with the ores and flux. The retorts at the outside of the lining were to receive the remainder of the coal, which became coked in descending the retorts, which were heated by burning gases in flues surrounding them. These retorts were continued downward, separately, from the central part of the furnace nearly to the hearth, so as to keep their contents distinct and to insure the coke formed in them being interposed at the hearth between the ores or metal and the blast jets. This plan of furnace was intended to secure that the coke should be at all times between the blast and the ores, and the writer anticipated from such an arrangement an increase in the production of carbonic oxide, a regularity in the smelting process, and a saving of fuel. He had not, however, had an opportunity of putting such a furnace in practice, but he was in the mean-

time altering a furnace with the view of making the experiment.—*Bulletin of the American Iron and Steel Association.*

THE PENNSYLVANIA STEEL WORKS AT HARRISBURG.—We collate the following interesting facts and figures from the correspondence of the Philadelphia "Press:"

The Bessemer Steel Works, established 3 years since, a few miles east of Harrisburg, are in successful operation, and their business is constantly increasing. The president is Samuel M. Felton, long and favorably known from his able connection with the Phil., Wil. & Baltimore R.; and the secretary, Chas. S. Hinchman, Esq.; and Robt. H. Lamborn, treasurer. The steel works are now turning out over 1,000 tons of steel rails per month, and during the balance of the year they expect to make 15,000 tons per month, and next year 25,000. This is the first mill constructed in America especially for this branch of manufactures. Nine hundred thousand dollars are invested for machinery alone, so that they are enabled to make heavier shafting than any other establishment in our country. Their new hammer, having a 35,000 pounds weight, cost, with its appointments, $92,000, and is the largest in the United States. The anvil block of this hammer weighs 150 tons, of cast-iron, and rests upon an immense structure of solid piling, reaching to the rock, set in and under the earth.

All the rails made by this Company pass beneath this ponderous rule, which by means of relays of skilled laborers is kept in operation night and day. The high quality of rail secured by its use is already recognized by the best engineers of the country. It was through the urgent advice of J. Edgar Thomson, president of the Pennsylvania Central, that it was erected. The use of smaller hammers, although producing a rail such as is usually placed upon the market, was not capable of satisfying the fastidious officers of that Company. New machinery for still higher perfection is already projected. This expense of $92,000 is, therefore, solely to increase the toughness and improve the quality of the rail.

The greater part of their work is done by machinery, with a hydraulic apparatus, by which the ordinary labor of 200 men can be accomplished by a single hand. They own 100 acres, which is traversed by the Pennsylvania Central Railroad, and quite a settlement has sprung up in that vicinity.

Some idea of the extent of these works, and capital employed in them, may be gained when it is known that they turn out $100,000 worth of steel rails per month. They furnish rails not only to the Pennsylvania Central, but to nearly all other roads throughout the United States. Col. J. G. Stephens, resident engineer, expresses the opinion that while iron rails wear out in 8 years, steel rails will outlast 17 iron rails. The labor is of an exceedingly intelligent class, as most of the work is done by machinery, and the workmen are required to perform very delicate chemical operations. A skilful chemist is continually employed testing the products of the work and the materials used in the manufacture of the rails and forgings, that they may be kept uniform and up to the highest standard of excellence. The manager, J. B. Pearce, worked for more than two years in various Continental and English steel works before connecting himself with this establishment. He is a graduate of Yale College.—*Chicago Railway Review.*

THE French iron trade is feeling more and more the effects of the war. In the Champagne district there is still a certain amount of business doing, but in the Moselle group matters have changed greatly for the worse. Thus some of the Longwy ironmasters have decided on blowing out their furnaces; at Stiring the forges and furnaces are stopped; and at Ars a furnace has also been stopped. The mineral workings of the Moselle are, it may be added, pretty well deserted. The French Government has given out an order for a large quantity of bullets and cannon balls to Messrs. Petin, Gaudot & Co.; the order to be executed with the utmost possible dispatch. Fresh orders for armor-plates are also spoken of. The imports of iron minerals into France in the first five months of this year amounted to 228,905 tons, of which 92,117 tons came from Belgium, 46,783 tons from the German Association, 41,580 tons from Spain, 70,243 tons from Algeria, etc. The Belgian iron trade is also beginning to suffer more and more from the war, scarcely any fresh orders having come to hand. The Luxemburg ironmasters propose, however, to make efforts to keep their blast furnaces going; the construction of some new works at Esch will also be continued. Official statistics just issued show that the export of rails from Belgium in the first five months of this year was 50,617 tons, against 41,895 tons in the corresponding period of 1869, and 27,597 tons in the corresponding period of 1868. The Belgian coal trade still displays considerable activity; thus orders have been received from Dutch undertakings which formerly used Prussian coal. The Eastern of France Railway Company, which has for some time received a large tonnage of coal from Saarbruck, is also about to use increased quantities of Belgian coal.

THE last two blast-furnaces built by the Ferry Hill Iron Company, Cleveland district, England, are 103½ ft. high, 27½ ft. at the bosh, and 8 ft. at the hearth. The average make of each is 550 tons weekly. The consumption of coke is 16 cwt. per ton of iron made, and 9¼ cwt. of limestone per ton of iron when forge iron is produced. The blast is supplied by six tuyeres to each. A cast iron pipe is carried around each surface, from which smaller pipes branch off at equal distances to the tuyeres. These pipes are covered bya non-conducting composition, but wrought-iron pipes are being fixed in place of these, lined with firebrick inside 4 in. in thickness. The furnaces are plated outside, and closed at the top on the cup and cone principle. The blowing-engine for the two furnaces has a 67-inch steam-cylinder, 130-inch blowing-cylinder, 10½-foot stroke. The stoves used are those invented by Mr. Thomas, and heat the blast to 1,400°. Four stoves are required for each furnace. Each stove has two rows of pipes; there are 9 double pipes in each row, 11 ft. in length; the pipe is of the flat form, the two passages in each being 13 in. by 4 in. inside, divided by a partition 1 in. thick, the whole of the metal being of that thickness, which renders them much lighter than the old form of pipes. The new stoves are calculated to last for 20 years and upward. The cost of one stove is about £170, or for four to supply one blast-furnace the cost will be £680. The blast enters at one side of a row of pipes, and must pass through 9 double pipes before it makes its exit at the other side. The advantages claimed by Mr. Thomas are, durability,

owing to the great length of heating surface, uniformity of temperature, and lightness of cost. It has been ascertained in practice at these works that no advantage is gained by heating the blast above 1,000 deg. temperature; no increase of make was obtained by raising the temperature from 1,000 deg. to 1,200 deg., and it is considered a further increase to 1,400 deg. would have a similar result.—*Bulletin of the American Iron and Steel Association.*

MM. Girard and Poulain have discovered a mode of freeing iron from its most mischievous impurities, which looks very promising, and deserves the attention of iron manufacturers. The first step in the process is the formation of an alloy of iron with one of the alkaline metals, it may be either sodium or potassium. This is done by forcing the vapor of one of the latter metals into a mass of molten iron. It is unnecessary to say that this part of the process is expensive, and is hardly such as could be carried out on a manufacturing scale, but the inventors profess to be able to bring about the same result in a cheaper and easier way. They say that if the coal or coke used to reduce the iron be saturated with a solution of carbonate of soda and dried before it goes into the furnace, or if common salt be employed with the fluxing materials, metallic sodium enters into combination with the iron. It may be so; but at present, so far as we know, there is only the assertion of the inventors for the fact.

An alloy of iron with sodium or potassium, when made by the first-mentioned process, is said to be very hard, but nevertheless malleable, and can be forged and welded. Either alloy oxidizes quickly in air or water, and when a current of moist air or moist carbonic oxide is sent through while it is maintained in a state of fusion, as in a Bessemer's converter, the alloy is decomposed and the alkaline metal is said to combine with any metalloids, as silicium, sulphur, or phosphorus, and in this way these latter are removed from their mixture with the iron. The final result of the operation is therefore a pure iron, but under some circumstances not defined in the paper we quote from, steel is said to be produced. This is the third process we now have for refining iron by the aid of soda salts. Which is the best of the three we must leave manufacturers to determine

Incidentally, the authors mention a curious alloy of sodium and potassium. This is composed of 4 parts of the latter with 2½ parts of the former; and it has exactly the appearance and consistency of mercury, remaining liquid at the ordinary temperature of the air.

Taking the Dross from Furnaces.—The invention of Mr. G. d'Adelsward, Paris, consists, first, of a cast-iron cistern, divided into two compartments by partition—the cistern is constantly kept full of water; second, of two hydraulic presses or other lifting apparatus, each having a plate or platform. These plates are intended to carry small wagons, which remain immersed to receive the dross. The presses work alternately, so that there is always one wagon receiving dross. They may be worked by a natural water-pressure, when obtainable, or by an arrangement of accumulators. The presses are only mentioned here as a means of lifting the wagons, and they might be replaced by cranes or by any suitable lifting apparatus.—*Mining Journal.*

## RAILWAY NOTES.

Grades and Curves.—The modern locomotive makes it possible to use much heavier grades and sharper curves than were formerly thought admissible. In the report of Mr. John Fanderson, Chief Engineer of the Portland and Ogdensburg Railway, he refers to the heavy character of the work shown by the surveys, and says:

But nowhere will there be required so steep a grade line or such heavy work, by from one-third to one-half, as on railroads now and for many years in successful operation in this country. In point of fact, while more than double the rise per mile of the maximum grade planes exacted by this pass have been overcome by locomotive engines in the regular traffic of railroads across the Alleghanies, there have been in New York and in New England single cuts which involved more excavation than would be required by the 3 miles under consideration, and single miles of greater cost of construction than the aggregate of these three. As instances, I may adduce an earth cut on the Sullivan road in New Hampshire of 240,000 cubic yds.; another of 235,000 cubic yds., 55,000 of which was rock, on the Midland road in New York; and a through rock cut of 111,000 cubic yards on the Montclair road in New Jersey. While as to gradients, although many instances might be cited, I think the following extract from a letter of Mr. H. D. Whitcomb, Chief Engineer and General Superintendent of the Chesapeake and Ohio Railroad, will be deemed sufficient to sustain my position, and to show what has been accomplished in the practice of traversing mountains by railroads. Mr. Whitcomb, under date of Dec. 24, 1868, says, in relation to a line of railroad crossing the Blue Ridge:

"The track was 5½ miles long, maximum (grade) on tangent 278 per mile, on curves 250 ft. per mile; minimum radius (of curves) 232 ft. Some of these curves were on trestles 40 ft. high. We used this track from 1854 to 1857 without an accident, except in a trial trip, and that not serious, and not the fault of the road, but of the brakes on the car.

"Since that track was made we have made another at a point further west, to avoid some very heavy work which we did not have money enough to complete. We have been working that for 11 years without an accident. The maximum grade is 308 ft. on curves of 500 ft. radius. The minimum radius is 400 ft. on 252 ft. grade. Our ordinary engines traverse this tract with the assistance of the engines formerly used over the Blue Ridge track.

"We are now constructing a third track still west of this point and on the grade ascending the Alleghany. We have on this grade a tunnel 3,600 ft. long, and at the eastern end of it an embankment 185 ft. deep. To avoid this temporarily, we are now constructing a grade of about 280 ft. per mile on curves of 600 ft. radius. * * *

"The usual load drawn over the 308 ft. grade by these Baldwin engines is 3 loaded freight cars, a gross weight of say 50 tons; but they will draw 4 cars. The speed we adopt is from 5 to 6 miles per hour. We have in our mountains in the winter

both snow and sleet, the latter as bad as you ever have it."—*American Railway Times.*

LOCOMOTIVE STATISTICS.—The annual report of Mr. J. A. Jackman, Superintendent of Machinery for the Chicago and Alton Railway, contains a few interesting facts. The Company has 108 engines, of which 84 burn coal, and 24 burn wood. The average number of miles run to a ton of coal was 37, average miles to a cord of wood 42. Wood costs $6 per cord, and coal $2 92 per ton on the tenders. The average cost for repairs for a mile run is 9.20 cents, and it costs 2 cents per mile run more to repair the coal burners than it does the wood burners. Of the 2,543,397 miles run by all engines, 1,438,506 were run by freight engines, 584,519 by passenger engines. The following table gives the full cost of locomotive service for the year:

| | | |
|---|---|---|
| Total cost of repairs | | $235,038 57 |
| Wages of engineers and firemen | | 178,845 91 |
| Cost of fuel | | 260,256 26 |
| Cost of oil and waste | | 26,702 89 |
| Cost of cleaning engines | | 37,360 87 |
| Cost per mile run for repairs | $9 20 | |
| For engineers and firemen | 7 00 | |
| For fuel | 10 23 | |
| For oil and waste | 1 04 | |
| For cleaning engines | 1 47 | |
| Total cost per mile run | —— | 28 91 |

against 31.41 cents the previous year. Included in the cost of repairs during the past year is one engine entirely rebuilt. Most of the engines were built by the Schenectady Works and the Rogers Works; although a few were made by others, including four or five built at the Company's shops. The prevailing size of cylinders is 16×24; drivers 60 to 68 in., 4 to an engine. Mr. Jackman says: The intention has been, and still is, not to allow the motive power to depreciate; and to fully compensate for any depreciation that might by any possibility have occurred, new works, in the shape of new boilers, new fire-boxes, new wheels and axles, new tyres, new parallel rods, new tanks and tenders, and all other parts of depreciative machinery, have been added in sufficient quantities to cover that portion of insensible depreciation which, to a greater or less extent, is common to all operative machinery, and which cannot always be compensated for by the general repairs, however thorough these repairs may be.—*American Railway Times.*

MINING ENGINES.—Messrs. M. Baird & Co., of the Baldwin Locomotive Works, Philadelphia, have built during the present year a number of small locomotives for use in mines, hauling away cinder, etc. The engines referred to are miniature locomotives, adapted to narrow gauges of 2½, 3, or 3½ ft. The Thomas Iron Works, Hokendauqua, the Lehigh Crane Iron Works, Catasaqua, and the Glendon Iron Works, Easton, are each now working 2 of these machines for hauling away cinder from their furnaces. At the former establishment the 2 engines do the work which formerly required 30 mules. The economy of their use is therefore manifest. For out of door work, the little engines are built with outside cylinders 9 in. in diameter and 12 in. stroke; the driving wheels are 30 in. in diameter. For mining purposes the cylinders are placed inside, the extreme width is reduced to about 5 ft., and the extreme height to 5 ft. 4 in. When running in the heading of a mine, it is intended that coke shall be used as a fuel, so that little or no smoke or gas will be produced. These engines, in complete working order, with tank of water on boiler, and a man on the footboard, will weigh only from 6 to 8 gross tons.—*Miner's Journal.*

WE have received the following description of an Elastic Railway Rail from Mr. F. A. Meredith, Mount Airy, Carroll County, Md., the inventor and patentee:

The improvement consists of Rail, Base, and Cap or Head. The base rail is in the shape of a U, with the prongs upward, and the base at the bottom to rest on the ties. This forms a solid rail with a groove in it. This groove is set with spiral springs, side by side. These springs have 3 rounds, or more if necessary, and any power can be had from them that is wanted for rolling freight. The cap of steel has a tongue to its head or cap, neatly fitted into the groove of the base rail on the spring. This rail is put down on the spring tight enough to take the less motion off the spring. The cap is held to its place by bolts put through the groove and tongue of the cap. The holes in base fit the bolts neatly, and the holes in the tongue are larger than the bolts, so as to allow the springs to work, and for expansion and contraction. The springs are not allowed more than an eighth of an inch play, when the engine is pounding the track. The joints of this rail are broken by each other; the ends of the cap rail have a tongue and groove fitting together. So when the engine comes near the end of the rail it brings the other rail down so as to form a smooth surface—that it will appear as a solid rail. Now if the cap should break, it cannot get out of place; and, if it should, the engine would run on the base, which is stationary.

When the rail wants replacing, all to be done is to take the bolts out which hold the cap and the cap set in. This track is not likely to break an engine tyre, as it is not solid enough.

When the engine is in a slow walk the track will be a solid rail, but at full speed it will give sufficiently to take the heavy pounding from the top, thus saving both rail and machinery.

BROKEN AXLES.—In the late annual report of L. J. Fleming, Chief Engineer and Superintendent of the Mobile and Ohio Railroad, after saying that accidents from defects in machinery, except from broken axles, had diminished, the following remarks on the causes and prevention of broken axles are given:

"The accidents from broken axles, principally under tenders, may be ascribed to two causes - the granulating effect of the heavy, rigid rail when laminated, and the very bad quality of metal of which axles are frequently made. Manufacturers generally believe there is no method of testing the quality without breaking the axle, and when accidents occur, that they will be attributed to the effects of granulation from vibration and impact; and that there is no means of tracing them to the bad metal of which they are made. For some time past all new axles have been ordered of sufficient length to take a fracture from each end, and one or two of each lot has also been broken in the centre. The result of these tests has been to return to the makers ¾ of those ordered within the past year. In future orders, the names of the makers will be required on each one, and the pro-

per credit or blame will be given in the annual reports. The person who manufactures a bad axle, on which the lives of so many passengers depend, whether it is done intentionally or from the want of a proper knowledge of making it, is as culpable as the person who places an obstruction on the track to throw off the trains."—*Engineering and Mining Journal.*

PERUVIAN RAILWAYS.—Peru is constructing three great railroads to connect her coast with the countries east of the Andes. The one from the coast to Arequipa, and across the Andes to Puno, and thence to Lake Titicaca, on the dividing line between Peru and Bolivia, is progressing rapidly. Forty miles have been finished between Arequipa and the coast, and traversed by powerful engines with construction trains. There are 6,000 laborers at work on the road. The difficulties of the mountainous ground are tremendous, but they have been hitherto triumphantly overcome. Many of the huge cuttings and embankments have called out the highest kind of engineering skill. Within 6 months, the ancient city of Arequipa, founded by Pizarro, away up in the vale of the Andes, will be in close communication with the coast. The region around Arequipa is rich in silver and copper mines, and produces cotton, wool, sugar, and nitre, the exports of which have been comparatively inconsiderable for want of cheap transport. This the railroad will give, and will inspire new life into the commercial and social relations of those productive but hitherto little known elevated valleys of the Andes.—*Commercial Advertiser.*

IN a letter to the "Times" Sir Joseph Whitworth makes a suggestion relative to the construction of railway axles, which is deserving of attention by the engineers of railways. He proposes that a hole should be drilled through the centre of the axle, throughout its length, thus opening up to inspection and examination that part of the material which, in the case of ordinary manufacture, is most subject to unsoundness. The hole should be about 1 in. in diameter, and, with suitable mechanical arrangements, might be drilled at an average cost of about 1s. 6d. per axle. With the outside turned and the inside thus exposed to view, a serious flaw in an axle, which is only about 4½ in. in diameter, could hardly escape discovery. The plan, he says, would also diminish the tendency of the axle to get heated, and by removing the material near the neutral axis, would, under the circumstances, reduce the internal strains, and render the axle safer.—*Railway News.*

BESSEMER STEEL RAILS IN FRANCE.—The use of Bessemer steel rails is extending daily in France. MM. Schneider & Co., of Creusot, have contracted to supply the Paris, Lyons, and Mediterranean Railway Company with 20,000,000 tons at £10 per ton at the works. They have also contracted to supply the Orleans Railway Company with 2,000 tons at £10 6s. per ton, to be delivered at Saincaize.

AMONG the noticeable inventions which interest railway managers is one of Mr. Wm. S. G. Baker's, of Baltimore. It is essentially a mode of making the cylinder steam-chest and bed-plate of locomotives in one piece.

The advantage of this mode of construction is in reducing the weight of the engine and lessening the number of steam joints.

The steam-chest, moreover, is, by this arrangement, formed within the bed-plate, and being covered by the smoke-box, there is less loss of heat from radiation than in the common plan.

Some engines have already been built upon this plan.

THE Hannibal "Courier" describes an invention of Mr. Stephen M. Richards, a superintendent of the Pullman Palace Car Lines west of the Mississippi, for the improvement of railway tracks. It consists in supporting the rails in spring attachments upon rubber bearings 1½ in. in thickness, set in sockets upon the cross ties by a patent fastener. The rail fastenings, too, are Mr. Richards' invention, and are so formed that a rail can be removed in an instant by removing a small screw. The Hannibal and St. Joseph Railway are preparing to lay a few miles of track with this improvement, and Mr. Richards has visited Chicago, to lay his invention before several roads.

## ORDNANCE AND NAVAL NOTES.

THE WHITWORTH GUN IN FRANCE.—A document has come into our hands which indirectly throws considerable light upon the present condition of the field artillery of the French army. It will be remembered that Sir Joseph Whitworth sent to the last Paris Exhibition two specimens of his steel field-pieces, the one a 10-pounder and the other a 3-pounder. These guns, having attracted the notice of the Emperor, were sent by his desire in the first instance to Versailles, and afterwards to the camp at Chalons, for exhaustive experiment, under the direction of the Commission Permanente d'Experiences, and it is their report which we have now before us, dated so recently as last year. It is a most valuable document as a record of the performance of English field guns in the French camp, but its chief interest at the present moment lies in the undoubted evidence which it affords of the great inferiority of the field guns, made of bronze, with which the French artillery is equipped in the war with Prussia, at least as compared with English steel guns. This evidence is supplied by a series of tables near the end of the report, in which the performances of these latter guns are compared with those of the "*canon de quatre de campagne*," as regards range, lowness of trajectory, retention of velocity at long distances, and accuracy. In all these particulars the French bronze gun was much inferior to both of the steel guns, and in some respects is so inferior as to bear no reasonable comparison with them. Even at 5 deg. of elevation, the range of the 3-pounder exceeds that of the French 10-pounder by 290 metres, while the English 10-pounder exceeds the other by 440 metres. But as the range increases, the inferiority of the French becomes much more marked. Thus, at 10 deg. the French gun ranges 2,350 metres, the English 3-pounder 3,120, and the English 10-pounder 3,320. At 20 deg. the ranges are 3,480, 5,000 and 5,490 metres respectively; and at 30 deg., while the range of the French gun is but 4,100 metres, the English 3-pounder has a range of 6,100, and the 10-pounder 6,890 metres. These inferior ranges of the French gun are associated, as they must be, with correspondingly high flights

or trajectories, rendering the aim of the artillery-man very uncertain in the field, where distances have to be judged hastily and by the eye alone. In ranging 2,000 metres the French shell rose to a height of 83 metres, while the highest point of the trajectory of the 3-pounder was 54 metres, and of the 10-pounder only 51 metres. At 3,000 yards' range the *maximum* ordinate of the trajectory of the last-named gun was 130 metres, that of the 3-pounder 137, and that of the French gun 253 metres! Those who understand the relation between a low trajectory and good aim in the field will discern the immense disadvantage of the French gun in this comparison. Not less remarkable is its want of *conservation de la vitesse*, or the quality of keeping up the power to hit hard throughout its flight. The initial velocities of the projectiles of all three guns were nearly alike, varying between 331 and 361 metres per second; but after travelling 1,000 yards the velocity of the French projectile fell to 247 metres, that of the steel 3-pounder being still 302, and that of the 10-pounder 311 metres. At 2,000 yards the velocities were 194, 276, and 282 metres; and at 3,000 yards 166, 252, and 264 metres. As the penetrating effect of a shell depends upon its velocity, it is easy to see how inferior the French arm must be in this respect likewise. Its inferior accuracy is also very remarkable, especially at long ranges, but we have not space to record all the figures. Those already given are taken without alteration from the official report. It is only necessary to add that bronze is of less than half the strength of good steel, or of Whitworth metal, and that much of the inferiority of the French gun is attributable to its use, it being quite impossible to fire the full charges of powder and length of projectile from a bronze gun of given bore without speedily destroying it.—*Times.*

An experiment was made recently at the Easter-road Barracks by the Edinburgh Militia Artillery, which is noteworthy as probably the first time that heavy guns of position have been handled with ease and rapidity without horses, bullocks, or elephants. By means of Thomson's road steamer two guns of 50 cwt. were moved at 6 miles an hour, and wheeled while moving at that rate in a space 8 yards in breadth. They were placed in position with a precision and rapidity that could scarcely be attained by any other means with guns of equal weight. This, it may be remarked, is the first time that Thomson's road steamers have been actually applied to heavy artillery. It is extremely probable that they will be largely used in future military operations. We understand that a number of these engines are being made for the British and Indian Governments, and that they will in future probably be in constant use by all civilized armies. Friday's work will, therefore, be quoted in future as the commencement of a new and important application of steam to warlike purposes. We understand that Mr. Thomson has offered the loan of engines to transport the guns in charge of our regiment of Militia Artillery to Dalkeith. The value of the appliance can be judged when we state that these heavy guns could be brought into action, at Dalkeith, which is six miles from Edinburgh, within an hour and a half after the order was received from Edinburgh.—*Engineer.*

The 35-Ton Gun.—Our Woolwich correspondent states that the large gun now in course of manufacture at the Royal Gun Factories, Woolwich, is expected to prove the most powerful piece of ordnance ever produced, and to settle definitely the long and hitherto even contest between guns and armor. It will weigh 35 tons, and will hurl a projectile of 550 lbs. with a charge of 100 lbs. of powder, thereby imparting an initial velocity which will enable it to pierce an armor plate of iron 15 in. in thickness, beyond which no ship meant to float can surely go. The barrel is of steel, strengthened at the breech by a strong iron jacket, and the calibre of the bore is about 11½ in., but this point has not been definitely settled. Indeed, the gun is at present altogether experimental, but if it answers expectation it is easy to guess what a formidable foe it will be to the iron-clads.—*Pall Mall Gazette.*

On the subject of the fortifications of Paris, the "Journal Officiel" says:—"One newspaper still dares to put questions respecting the armament and the fortifications of Paris, although it is an act of treason to speak thus in the presence of the enemy. Insinuations like these make it necessary to reply, in spite of the evident danger that there is in doing so. All the armament of Paris is in Paris itself. More than 600 cannon are already on the ramparts of those forts which will be first menaced; others are being placed in position continuously day and night with the greatest activity. On Saturday 7,500 workmen were employed in cutting the roads that lead into Paris. These cuttings have all been made, and there now only remain the details necessary to complete the preparations for closing the draw-bridges. Thousands of workmen are occupied outside the city upon the earth-works, which will complete the *ensemble* of the permanent forts. These are the details and the figures which we are obliged to give in reply to perfidious and erroneous insinuations, and in order to re-establish the confidence of good citizens. If such questions are renewed, it is before the Council of War that their authors will have to answer for their conduct. They will undergo all the penalties of the law, for these are times when, less than ever, it can be permitted to slumber."

The Prussians were unanimous in declaring the Chassepot inferior to their own Dreyse. "It certainly has the wider range," they said, "and sometimes kills a man at the most unexpected distances; but then you cannot take aim at above 900 paces, and what is the use of blazing away unless you have a fair chance of doing execution? Besides, the immense range of the gun interferes also with your taking aim at short distances, and the large quantity of powder in the cartridge makes it impossible for any one to stand the recoil. You cannot properly handle a gun that boxes your ears. We have frequently seen men pressing their guns against their breasts and thighs when firing. If the chassepot could be pointed and discharged by a machine, it would be a terrible weapon indeed." The mitrailleuse is voted an exceedingly unpleasant thing by the Prussian soldiers, "but then, you see,"—they will add qualifyingly—"they always fire as straight as you can go. The moment you turn a little to the right or to the left you are safe. It was always much easier for us to evade the balls than for the French to alter the aim of the mitrailleuses."—*Prussian Correspondent of the Times.*

A FINE gun has arrived at the Gun Wharf, Devonport, from Woolwich, for the iron-clad ram "Hotspur." It is a 12-in. muzzle-loading rifled gun of 25 tons (Fraser's construction), and carries a 600 lbs. shell, with a battering charge of 67 lbs., and a bursting charge of 35 lbs. of powder. It is rifled with 9 grooves, and its cost exceeds £2,000. This gun of Fraser's construction is an improvement on the original Woolwich gun; it has only 2 coils, which, together with the trunnion, are forged on to the tube, and they are so incorporated that the gun may be fairly described as being in 2 pieces only—the tube and the united coils and trunnion. With the original construction there were in the 8-in. 9-ton guns 4 rifled grooves and 5 coils, which latter entailed a vast amount of labor and expense in construction, besides which it was found that these coils, being so numerous, were subject on heavy firing to loosen and shift, which was especially the case with the 12-pounder field gun made on the same principle; but with the improved Fraser gun this cannot occur.

ABOUT 300 men (including more than 100 from Woolwich alone) have been enlisted and passed the medical examination at Woolwich for the Army Service Corps since the order to enlist for this corps was issued. 500 men are to be added to the corps, and three additional companies will be formed in the transport branch and two in the supply. Many recruits have also joined for the Royal Artillery and other corps. Though there is no bounty given, young men are offering themselves in great abundance, the reduction in the standard having opened the ranks to many who have been precluded only by their insufficient stature from joining the army long since. Specimens of the French chassepot and the Prussian needle-gun are exhibited to the public in the Rotunda at the Royal Military Repository, Woolwich.

WE understand that the Lords of the Admiralty have decided upon making some valuable additions to the iron-clad navy, and have called upon the leading shipbuilding firms in the United Kingdom to tender for the construction of 4 vessels of the "Scourge" class. It is also intended, we believe, to build 2 other ships similar to the "Cerberus."—We have reason to believe that even if the war now being waged on the Continent has an early termination, the "Flying Squadron," which was to have left our shores in October, will not now be despatched. Public confidence has received a shock, and cannot be easily restored.—In a trial of sailing last week the "Repulse" showed that she had the heels of the whole Coast-guard Squadron, beating the "Achilles," which has obtained a celebrity as having beaten the fastest iron-clad under sail of the former Channel Squadron.—*Army and Navy Gazette.*

A NEW method of converting the Enfield muzzle-loading rifle into a breech-loader was tried in the Royal Arsenal, Woolwich, on Tuesday evening. It is the invention of Mr. T. Restell, of Birmingham. The breech arrangement consists of a steel block, which is moved horizontally to the right by the cocking of the rifle, and when the cartridge is inserted the pull of the trigger closes the breech and fires the rifle simultaneously. The chief merits of the invention are rapidity, simplicity, and cheapness. In the hands of a rifleman who had not seen the weapon before, it made on Tuesday 27 rounds in 2 min., with a score of 68 points. The Enfield, it is stated, can be converted into a breech-loader on this principle at a cost of 5s. each.

NEWS has been received of the expedition of Sir Samuel Baker. On June 13, he was at Tewfikiyeb, lat. 9.26 N.

## ENGINEERING STRUCTURES.

THE WORK ON THE BROOKLYN PIER OF THE EAST RIVER BRIDGE.—The lower edge of the great caisson is 29 ft. below high water, and is steadily going down. The fourth course of masonry is being laid on the top. The water shafts have been lengthened upwards, and the air shafts are to be treated likewise at once.

An interesting experiment was performed recently under the caisson.

It must be remembered that the water shafts through which the excavated material is raised, extend downward about 6 in. lower than the edge of the caisson. A pit is kept about each shaft, into which the workmen below dump from barrows the earth to be raised through the shaft by the dredge.

A large boulder was recently found at the bottom of one of the pits. It became necessary to remove it with as little delay as possible. The water shaft was fitted with a tight cap of boiler-plate iron (which the foresight of the engineer had provided in the original plan), and an air connection was made between the caisson-chamber and the upper portion of the water shaft.

The water of the shaft, which always stands at the height of the water in the river, ran quietly down and away under the edge of the structure.

To sink the pit to sufficient depth to remove the boulder the water had to be got rid of. So pumps were sent down, and the pit, beginning at the bottom of the river, was sunk 12 or 15 ft. further, with the same means and with as few hindrances as it would have been in the open air. The stone-workers followed the pumps, split the boulder to fragments with wedges, left the pit to fill with water, when the cap on top being removed the water filled the shaft to its wonted level, and the ordinary routine was again pursued.

This operation at one shaft did not interfere with the work at the other, about 20 yards distant.

ELECTRO-MAGNETIC ENGINES AGAIN.—The French journal "Le Nouveau Monde," published in New York, contains an account of the operation of a new electro-magnetic motor, invented by Mr. E. Prevost, which we would not notice if our criticism did not with it carry an instructive lesson. The account says:—

"It has been believed hitherto, that the power produced depended on the number of elements used in the electric battery. This Mr. Prevost denies. In the same way as one single spark is sufficient to ignite as well a ton as a grain of gunpowder, so Mr. Prevost proves by facts that with two elements of Bunson, 8 in. high by 6 in. in diameter, electro magnets may be charged developing a power of 8,000 lbs., whatever be the difference of the force, size or number of the electro-magnets submitted to the influence of the battery.

We have seen with our own eyes that the number of the electro-magnets was increased without the least loss of force in any of them, and that the operator then removed several of them without the least increase in the attractive force of those remaining.'

Then the account goes on with the stereotyped and erroneous statement that the expense is very small. The inventor is, of course, "ready to satisfy the incredulous public, by experiments on a large scale, that the invention possesses great practical advantages." etc.

This is the same old story renewed. These experiments on a large scale have been made over and over again, and it is well-known by those familiar with the subject, that the "incredulous public' has been thoroughly satisfied, by that very means, that such inventions possess no practical advantages whatsoever.

The assertion made by the editor on the authority of Mr. Prevost, that the number of electro-magnets may be increased without loss for each individual one, proves only ignorance of the laws of electric currents. Ohm discovered the law of relation between the batteries and the wires discharging the currents, developed by the oxidation of the zinc and decomposition of the fluids in the battery. This law is called the law of Ohm; and, in order not to trouble our readers with the formulæ, we will only remark that its chief result is, that the battery works to its utmost capacity and utmost result when the resistance which the discharging wire offers to the current is equal to the resistance which the battery itself offers to the passage of the same current.

Metals are much better conductors than fluids surpassing them several million times; copper conducts the current 20,000,000 better than the best solutions in the battery, to which the resistance of the porous cups has to be added; consequently a Bunson battery of two cups is able to discharge its current through many miles of copper wire, without experiencing a resistance greater than the current has to overcome in the battery itself; how many miles may be easily calculated from the dimensions of the battery, thickness of wire, etc.

As long as the length of the wire is below this the whole power of the battery is discharged and no change in the currents of the wire and its effects on electro-magnets can be perceived, though we increase the length of the wire and charge, say 4, 8, or even 20, or 50 electro-magnets; but as soon as we increase the number of magnets so that the length of the wire surrounding them surpasses the limit at which the resistance it offers to the current is equal to the resistance offered by the battery, the whole power of the battery can no longer be discharged, and the power of the individual magnets will commence to decrease. These laws are of the utmost importance to the telegrapher, who has to overcome great resistances, produced by passing electric currents through long distances and over very long wires. In fact, these laws were discovered in the use of the electric telegraph; and every telegraphic electrician can tell this inventor that he is generally mistaken in his denial of the demonstrated fact that the "power produced depends on the number of elements used in the electric battery."

His comparison of a "spark igniting a ton as well as a grain of gunpowder" is quite out of place. Most inventors of electro-magnetic machines are at the present day in a much denser fog than ever were those who attemped to improve the steam-engine. They are, in regard to electric currents, on the same level as those are in regard to a steam pressure who ignore the law of Mariotte, the atmospheric pressure, and the theory of the crank or eccentric.

We recommend to all those who venture on this field a thorough study of the law of Ohm in its special applications to electro-magnetism. The most valuable work for them to study is Dub's "Electro-Magnetismus" (Berlin, 1861); it will cure them of their delusions. — *Manufacturer and Builder.*

ATMOSPHERIC TELEGRAPH – SUCCESSFUL TEST OF A NOVEL PROCESS IN ENGLAND. – Herapath's "Railway Journal" of July 16th, gives a description of experiments on the system of telegraphing invented by Signor Guattari, which substitutes atmospheric air compressed in a reservoir for the electric battery, and tubes filled with air for conducting wires. The apparatus consists of a reservoir of compressed atmospheric air, regulated so as to provide the requisite force of velocity with which signals are to be sent through tubes from one place to another. Vulcanized india-rubber tubing about half an inch diameter, said to be a mile in length, coiled round a drum, was attached to the reservoir at one end, and to another apparatus at the other end of the tube to receive and print the signals as given from the reservoir or battery end of the tube. The tube (of any suitable metal) is provided with a movable vent, by which more or less force can be given to the current of air by which the signal writing or printing mechanism is actuated. The signals are given by pressing a certain number of times on a piston by which pulsations are given to the air in the pipe or tube and transmitted through a valve to a lever connecting with the writing apparatus, marking on a moving strip of white paper the impulses given at the reservoir end of the tube. As the signals are given at one end of the tube, they are immediately printed at the other end in a similar manner to Morse's instrument.

An indicator shows the force of the current of air passing through the transmitting tube or pipe, as the case may be; and similar indicators are placed near each end of the communication. Several messages were sent through the tubes and printed at the other end. A long conversation ensued as to the velocity of the messages and the capability of the apparatus for various purposes. It was inquired on the part of the post office authorities how many words could be sent in a minute by the atmospheric telegraph; it was stated from 20 to 24 words could be sent by the present apparatus, the greater portion of which had been made by the inventor, and therefore its working was capable of being greatly facilitated and improved by a more skilful workman, so that he was confident that at least quite as many words could be telegraphed by the Guattari system as by the electric telegraph.

A naval apparatus was also worked showing how signals could be given to five different departments in a war steamer—to the engine room, the powder magazine, the steering, etc., and that

orders had been given for its adoption in the Italian navy.

The mode of telegraphing to one or more stations without the aid of the transmitting machine, or the necessity of the sender being confined to any one point, was shown.

Signor Guattari stated that his system was more economical and simple to construct and work than the electric telegraph; that it was free from atmospheric influences which so materially disturbed the electric telegraph during storms, and would not be so subject to accidents. It was calculated that the machinery and instruments could be provided and maintained at half the cost of those required for the electric system. There were no batteries to be renewed at considerable expense; and he maintained that any result attainable in the electric was equally attainable by using the Guattari system.

There seemed to be no doubt from the experiments that this system of telegraph would be effective for moderate distances for large establishments, ships, and towns, but that more extended experiments would be requisite to prove that it would be equally as efficient and certain as the electric telegraph for very long distances.

A set of the largest pumping engines yet made have just been completed by Messrs. Gwynne and Co., of the Essex Street Works, Strand; they are to be erected in Denmark for some heavy drainage works, to reclaim 20,000 acres of land for the Nissum Fjord Company, and of the most approved construction. The manufacturers are confident that the engines and pumps will raise 40,000 gallons (178½ tons 12 ft. high in one minute, which is nearly 50 per cent more than contracted for. The machinery consists of a pair of engines, 4 ft. apart from centre to centre, coupled, with one pump on each side. The engines are 21 in. cylinder expansive condensing, 21 in. stroke, mahogany lagged, running at 140 revolutions (490 ft. piston speed) per minute, and consuming 3 lbs. per horse-power per hour; vacuum, 27 in. The pumps are constructed on Messrs. Gwynne & Co's. well-known centrifugal principle, and are 42 in. diameter in the pipes. The same manufacturers will shortly have completed a combined pumping engine for the Punjaub Railway, to discharge 1,000 gallons per minute 60 ft. high.—*Mechanics' Magazine.*

The New Cable between England and France.—The new cable for the Submarine Telegraph Company, to be laid from Beechy Head to Cape Antifer, near Havre, a distance of about 70 miles, has been commenced at Mr. Henley's works at North Woolwich, and will soon be completed. It forms a large, massive cable, and will be one of the largest yet manufactured. The core consists of 6 insulated conductors, wormed and served in the ordinary manner; each conductor is a strand of 7 wires, weighing 107 lbs. per nautical mile, and insulated with 3 coatings of Chatterton's compound and 3 of gutta-percha to the weight of about 150 lbs. per mile. The severed core is sheathed externally with 12 No. O. B. B. galvanized iron wires, protected with 2 servings of tarred hemp and bituminous compound. The shore ends have a similar core, but are sheathed with 12 No. 0000 B. B. galvanized iron wires, protected with two servings of hemp and compound. This is the first time wire of such enormous diameter has been used for submarine cables. Land lines for this cable are being erected between London and Beechy Head, and Havre and Paris, so that the new line will be an independent one, and will tend to obviate, if not prevent, the delays which have frequently occurred in the transmission of messages between London and Paris, arising chiefly from a pressure of business. In future any breakage which may take place in the old and new lines will be quickly repaired, because, under the authority given lately, the Company will conduct repairs with their own repairing ship, instead of employing a tug, as hitherto.—*Mechanics' Magazine.*

Electric Buoy.—An electric marine buoy, the invention of M. E. Duchemin, was exhibited at Cherbourg some time since by order of the Minister to the Marine. The electricity was produced by the constantly-renewed action of the seawater on zinc, but the inventor has since carried on a series of experiments in order to ascertain if an increase of intensity could not be obtained as in ordinary batteries, by means of certain chemical substances held in suspension around the zinc or charcoal element. The new battery resulting from the experiments consists of a porous vase fixed on a wooden buoy or floater. The vase is surrounded by a thick zinc cylinder, pierced with holes, the wire of which represents the negative pole. Within the porous vase is placed a slab of gas-retort charcoal, to which is affixed the conductor of the positive pole: the charcoal is surrounded by pieces of coke and perchlorate of iron. The vase is carefully closed, and the battery when plunged in the sea immediately gives forth large quantities of electricity. A commission consisting of M. Becquerel, General Morel, and Marshal Vaillant, has been appointed to examine this marine electric apparatus.

## NEW BOOKS.

The Metallurgy of Lead, including Desilverization. By John Percy, M. D., F. R. S. London. John Murray, Albemarle street. For sale by Van Nostrand.

The continued improvement in the lead market coupled with the prosperous position of the mines of that metal in North Wales, will cause even more than usual interest to attach, at the present moment, to the exhaustive volume just completed by Dr. Percy, of the Royal School of Mines. The original intention of including the metallurgy of silver and gold, as well as that of lead, has not been carried out, and it is explained that it was found impossible to embrace the whole in one volume of convenient size. As usual with Dr. Percy's works, the subject is treated exhaustively, and as all the diagrams given are drawn to scale, the practical lead smelter is enabled not only to determine which process is best calculated to meet his requirements, but to put the process selected into actual work. The physical and chemical properties of lead are first considered; then the extraction of silver from lead, and lead smelting; and lastly, the preparations of lead compounds usually met with in the market.

With regard to the physical properties of lead, Dr. Percy tells us that it belongs to the class of

white metals, but has a decided bluish-gray tint. A freshly cut surface has a bright lustre, but it soon becomes dull from atmospheric oxidation. To the eye lead usually presents no sign of crystalline structure, though it is certain that the metal is an aggregation of crystals. Ihle observed very distinct octahedral crystals of lead in a cavity in a pig of lead from the Muldener Hütte, Freiberg; yet crystals sufficiently defined to admit of measurement by the goniometer have not been obtained. Lead is the softest metal in common use; it is very feebly elastic or sonorous, the dullness of sound being generally proportionate to the purity of the lead; and it does not cry, like tin, on being bent. Its specific gravity is about 11.38 when chiselled out of a very pure pig. Lead in a state of fine division may by mere pressure be made into a solid mass; thus, a paste of sulphate of lead and water is spread an inch thick upon a plate of zinc, and the whole is plunged into the upper part of a solution of common salt not quite saturated. After a few days the paste will be changed into a coherent soft mass of lead, which by immersion in hot water may be freed from the interposed solution of salt. Under a powerful press this mass becomes a solid plate of flexible lead, which stamped in a mould gives a sharp impression. If not strongly pressed, the mass readily oxidizes.

The chemical properties of lead are very fully treated of. The atomic weight, taking the average of the various authorities which Dr. Percy quotes, is 103.5. He describes the compounds of lead and oxygen, giving some very interesting particulars of the silicates of protoxide of lead; of lead and sulphur, recording a large number of carefully made experiments by Mr. J. C. Cloud, not previously published; of lead and carbon, mentioning the efforts that from time to time have been made to substitute the direct production of the carbonate of lead or white lead for the original Dutch process generally employed; of lead and arsenic, suggesting that nickel and cobalt should act like iron upon arseniuretted lead and phosphorus remarking that experiments by Mr. Cloud confirm the statement of Berthier, that there is no reaction between phosphate and sulphide of lead at a high temperature; of lead and chlorine, stating that according to Berthier litharge partially decomposes choloride of sodium by the dry way, and melts easily with chloride of barium or calcium, producing yellow crystalline insoluble oxychloride resembling Turner's Patent Yellow, from which water separates the excess of chloride of barium or calcium mixed with baryta or lime respectively; of lead and nitrogen; and of lead and antimony, explaining that when lead alloyed with antimony is calcined (say) at a moderate red heat, with free access of atmospheric air, both metals are quickly oxidized, but the antimony in greater proportion than the lead, antimoniate of protoxide of lead being formed, so that by means of calcination lead may be practically freed from antimony; and accordingly such a process is adopted on the large scale in what is termed softening.

Referring to the alloys of lead, it is stated that the alkaline reaction of a freshly-cut surface of the alloyed lead, prepared by Vauquelin by heating oxide of lead with cream of tartar, is fallacious as an indication of the presence of potassium, since it is found that upon laying a piece of moistened red litmus paper on a freshly-cut surface of the purest as well as of common commercial lead it becomes rapidly blue. Having referred to the alloys of lead and potassium, lead and sodium, lead and copper, and lead and manganese, he proceeds to describe the ores of lead, and inserts an admirable description by Mr. Warington Smyth, of the mode of occurrence of British lead ores. The assay of lead ores is also treated of, the principles both of the dry and of the wet way being thoroughly explained. Alluding to the wet assay of lead ores, Dr. Percy remarks that several methods have been proposed for the estimation of lead by means of standard solutions; but he is not aware that any have been successfully applied in the assaying of ores of lead. They either fail in requiring too much expenditure of time, from inaccuracy of the method from interference of substances often existing in lead ores, or from other causes. He believes that the dry method must always be resorted to as the only direct, accurate, and practical method of quantitatively estimating the silver in lead. Some of these methods have been tried in the Royal School of Mines Laboratory during several months, and have been abandoned on account of one or more of the objections specified.

The chapter on the extraction of silver from lead will be read with much interest, since it contains a complete account of the Pattinson process, and of the accidents which led to its discovery; and more especially so when it is remarked that Dr. Percy considered it desirable that there should be a permanent record from the pen of Mr. Pattinson himself, and therefore publishes a description which, with the exception of a few unimportant verbal alterations, is Mr. Pattinson's own, and which he prepared at his request for his use as lecturer on metallurgy at the Royal School of Mines. The same chapter also contains descriptions of Parkes' and other processes of desilverizing: of the decopperization of lead by zinc; of cupellation; and the refining of blicksilber.

The student being thus provided with an ample amount of preliminary information, the subject of lead smelting is dealt with, historical notices of lead smelting in Great Britain, and some useful introductory observations on lead smelting, being followed by the description of the furnaces and processes used, and results obtained by the Flintshire, Spanish, Cornish, Bleiberg, and other systems. Of the great value of Dr. Percy's work two opinions cannot exist; probably no one is better acquainted than he is with the literature of the subject and it would be scarcely possible to utilize the knowledge which his extensive study has placed him in possession of, in a more satisfactory manner than he has utilized it in the present volume. It is really a cyclopedia of lead smelting, which may be referred to with the utmost confidence, and few will require more complete information than the book will furnish them with. —*Mining Journal.*

AN ELEMENTARY COURSE OF PLANE GEOMETRY AND MENSURATION. By RICHARD WORMELL, M.A., B. Sc. Second Edition revised and enlarged. F. cap. 8vo., pp. 276. London: T. Murby.

This book is the work of a reformer, not so much of geometry, as of the mode of presenting it to the young. Sciences begin in practical ap-

plications, and tend by a universal law to become more and more abstract; and the doctrine of the reforming school is, that whatever the science may have developed into, it is necessary in teaching it to go back to practical applications, and to seek for a sure foundation for abstract notions in the familiar experience of common objects. Teachers need to be incessantly reminded of this necessity. In teaching physics, or chemistry, or botany, it is perhaps admitted, though not always obeyed; but in mathematics it is generally not admitted; and when admitted it is rarely followed out to its logical consequences. Geometry, arithmetic, algebra, must alike be presented first in their applications; and then alone, in most cases, can definition and soundness be given. In most cases, we say, because where mathematical talents of a moderately high order exist, as in the generality of mathematical teachers, this necessity is not felt. And for this reason, mathematical teachers who are not also observant of mental phrases, may be slow to believe what has just been pointed out as a necessity in their art. Many of them, we suspect, have a secret sympathy with the mathematician who proposed the health of "The prime numbers, the only branch of mathematics that has not been defiled by contact with the concrete."

The aim of Mr. Wormell's book is to teach scientific geometry, the logical dependence of truths on one another being shown, and to make the teaching sound by giving familiar illustrations of all the conceptions involved, and applications of the result attained. The book is interspersed with examples, geometrical and arithmetical. Among the subjects mentioned – we turn to the index, as giving a good idea of the book—are star polygons, axis of symmetry, graduation, land-surveying, spirals and volutes, transmission of motion by cogs, etc. Considering what the aim of the writer seems to have been, the illustrations and applied part of the book have been well done. It is generally clear, moreover, and accurate in style, and is interesting. In form it is adapted for a school-book; and for certain schools it may be a success. But it fails as a scientific geometry intended to replace Euclid in three respects; want of clear statement of axioms and exhibition of the science as rigidly deductive; the avoidance of the difficulty of incommensurables; and a degree of undefinable inelegance of treatment throughout. The book is too long, and is too nearly scientific, to use as an introduction to Euclid or to any of its modern substitutes; and, though it would replace them with advantage if the mathematical education of the student were to end with the reading of this book, it is not easy to see how the student proceeding to higher mathematics could do so without previously mastering another more complete geometry. It seems to me, therefore, a successful contribution to "technical education," and a valuable and suggestive attempt, but not altogether a successful one, to teach scientific geometry on true principles. The book is well adapted for middle-class schools. It is scarcely worth while to notice minor faults, either of the printer, which are very few, or of style. But it is really to be regretted that a degree should have been defined thus: "Suppose we have a circumference sufficiently large to be divided easily into 360 equal parts, each part is called a degree." A degree is an angle, and this conception ought to be prominently brought forward.—*Nature.*

A Sketch of a Philosophy. Part III. The Chemistry of Natural Substances. Illustrated by two folding plates and 150 figurate diagrams of molecules in the text. By John G. Macvicar, LL. D., D. D. Williams and Norgate, 1870.

It is a hard matter to give a just account of this pamphlet. The views propounded by the author are so entirely different from those usually held by chemists, and according to the author's own statement they have been so little studied by others, that it is difficult to know exactly how to treat the subject. We should scarcely be justified in saying that the whole system is mere imagination, though some hold this opinion; but the book, though evidently written with the intensest earnestness, is the work of an enthusiast, which will explain the bitter complaints he makes against modern chemists for not taking more notice of molecular morphology. The author endeavors to explain the formation of all matter by the aggregation of the ethereal element, supposing that all bodies tend to assume a symmetrical and more or less spherical form. The simplest form of aggregation Dr. Macvicar considers to be the *tetrad*, consisting of four specks of the material element so arranged in space that they form the angles of a tetrahedron, the lines joining them indicating the attracting and repelling forces operating between the units. Two tetrads are also assumed to join base to base producing the *bitetrad*, and from these two forms, the tetrad and the bitetrad all the atoms and molecules of our planet are supposed to be produced. This tetrad by attracting another unit opposite to one of its faces constitutes a group of five units considered to be the atoms of hydrogen, and with the atomic weight of five. The author proceeds to show the mode of genesis of many other elements and compounds by the juxtaposition of these elemental forms. By calculation he can determine by his system the specific gravities of solids and liquids referred to water as unity, in a manner similar to that by which the densities of gases and vapors may be deduced by the old system. This alone would seem to show that the method deserves more attention from chemists than it has yet received. The non-reception of this molecular morphology may be ascribed to several causes; the diction of the author is peculiar, and he writes in a dogmatic manner, which might be expected in a theological work, but is not usually found in a treatise on natural science; then he pushes his inferences to such an extent (or, as some would say, rides his hobby so hard) that his conclusions appear somewhat ludicrous, unsupported as they are by experiment; thus he traces the coincidence between the assumed hexagonal form of the molecule of aqueous vapor and the shape of the minimum snow-flake and ice-flower, and the "inflorescence of plants of the monocotyledonous order, in which an aqueous issue predominates;" he thinks that one of the forms of aqueous vapor which occupies half the volume of the other, may possibly be converted into the second variety at a high temperature, and thus explain the explosion of steam boilers. Again the dimorphism of water may be

the cause of the production of animal heat; for water in the body may be transformed from one of its varieties into the other with evolution of heat; but on escaping from the body as perspiration, the inverse action takes place and cold is produced. But underneath all these extravagances there may be a stratum of truth, and we hope that either the author or some one who understands and accepts his views thoroughly, will so develop them as to insure their reception by chemists.—*Nature.*

MICROSCOPAL MANIPULATION By W. T. Suffolk, F. R. M. S. Gillman, 1870. For sale by Van Nostrand.

This little book is the substance of a course of instruction given by Mr Suffolk in the spring to members of the Quekett Club. It will be useful to those persons who amuse themselves with microscopes, and do not care to purchase the scientific treatises of Dr. Carpenter or Dr. Beale. There is a chapter for the very youngest beginner on the various parts of an English compound microscope and their uses; then we have hints about the cutting of glass and the old directions as to making cells; mounting objects in balsam and in fluid is next dealt with, the old, old routine methods being detailed once again, with an allusion to Dr. Bastain's process with benzine. It is a pity that Mr. Suffolk has not made himself acquainted with some of the many methods of mounting and preparing objects in use on the Continent, which he might have picked up from Stricker's handbook, Frey's work, or other similar treatises. The best chapter in the book is that on polarized light, because it deals with a subject rather slighted in other works of this kind, in a clear and intelligent manner. We were not however, prepared for the following in a work on microscopical manipulation: —"The undulatory motion of light would seem to be expressed with considerable clearness in the 1st chapter of Genesis, when read in the original Hebrew, which, in common with other languages of the same family, is remarkable for the numerous inflexions of its verb, which gives it a delicacy and precision of expression unattainable in Western languages.' Mr. Suffolk is quite right in considering that more attention should be paid to the use of polarized light as demonstrating structure, than has been done hitherto. A necessary step toward this is that microscopists should properly understand what are the conditions of production of color with the polariscope, and not be content with the mere sight of a pretty display. This little book of Mr Suffolk's will not do much, we fear, to convert what we may call microscopical play into microscopical science. Its receipts and directions are such as will be useful to the man who cares merely to make a series of pretty slides for exhibition to his friends, but do not help the student wishing to add to the storehouse of science. Nothing is said of the manner of studying living objects, living cells, living cilia, living protoplasm; nor do we find an allusion to the use of chromic acid, section instruments, methods of embedding of gold and silver staining, or other processes important to a working microscopist. The gold and silver-staining methods might have been given, if only for the benefit of those who like to make gorgeous preparations.

A small book on "Microscopical Manipulation," well up to the time, would be useful to students. We are sure Mr Suffolk does not wish to claim this position for his digest of the older hand-books. His excuse for its publication must be that in this country there are many people who indulge in the expensive peepshows sold by our English opticians, to whom it will really be acceptable.

It must not be imagined that we for one moment object to such amusements; on the contrary, they are altogether to be commended where more serious work cannot be undertaken—and only then.—*Nature.*

REACTIONS SCHEMA FUR DIE QUALITATIVE ANALYSE, ZUM GEBRAUCHE IM CHEMISCHEN LABORATORIUM ZU BERLIN. Berlin, 1870. VERLAG VON AUGUST HIRSCHWALD. London: Williams and Norgate. For sale by Van Nostrand.

This is a kind of pictorial analytical table in which the characters of the precipitates obtained are indicated by colored oblong spaces, which will, doubtless, be found very useful for impressing the appearances of the different precipitates on the mind of the student. The borax bead obtained with a compound of cobalt is represented by a blue oval, and the effect of ammonia on red litmus paper is shown by an oblong half red and half blue. The changes of color produced by the action of sulphuretted hydrogen on salt of mercury are indicated by an oblong of four different colors—white, yellow, orange, and black.

It is unfortunate that this table is not more complete; thus no means of obtaining the solution to be treated is mentioned; the destruction of organic matter before precipitation by ammonia and ammonia sulphide is omitted; the possibility of the precipitate in the third group containing phosphates, and the mode of examining it under such circumstances, is passed over entirely. The spectra of potassium, sodium, and lithium, are indicated by black lines with fine transverse white ones, representing the colored bands; but unfortunately no means are given to show which is the more refrangible end of the spectrum. Besides these omissions there are some misprints which will no doubt be corrected in a subsequent edition. – *Nature.*

THE GAS MANAGER'S HAND-BOOK;" consisting of Tables, Rules, and Useful Information for Gas Engineers, Managers, and others engaged in the manufacture and distribution of Coal Gas. By THOMAS NEWBIGGIN, A. I. C. E. London: W. B. King. 1870. For sale by Van Nostrand.

The class of books to which the one we notice belongs are among the most useful that issue from the press; and this one from the variety and amount of information it contains may be fairly described as one of the most useful of its class. It is a book which will be thoroughly appreciated by those who until now have had to seek in a dozen volumes for the information here collected into one, and who have had to spend hours in making calculations here done to their hands. But having said this we cannot dismiss the work without remarking the want of method displayed in the arrangement of the materials. We might almost say that there is no attempt at arrangement at all. This defect is not altogether compensated for by a full table of contents and a tolerably copious index, and in the assurance that a book so useful must soon arrive at a second edition, we would

suggest an entire re-arrangement of the contents.

At the commencement the compiler very properly introduces the raw material of gas-coal, and on pages 2–7 gives a table of the quantity of gas obtained from different coals and mixtures. This table should have been preceded by that of Mr. Lewis Thompson, given on pages 13–21, and then the whole of the information respecting the raw material would have been kept together. Retorts (about which more might have been said) and the other apparatus of distillation would very properly have come next. Following the process, we should come to the condensers and purifiers and their contents. Proceeding, we arrive at the gas-holders, and the finished article, after which all the information relating to gas might be given in proper order. The distribution would naturally come next, and we should have all that relates to mains and joints, and the flow and measurement of gas. The manufacture and distribution being thus followed step by step, the various tables and useful information, which scarcely admit of classification, might succeed, and the book be fitly concluded by the long tables of discounts, and the arithmetical tables. In th s way the information given would be systematized, and a scientific character given to the book, which in its present state it scarcely possesses. We throw out this suggestion, which our space will not allow us to further develop, in the hope that the compiler will take it into consideration when preparing a second edition.

In conclusion, we may say that we noticed but few errors in the book, and these of but little importance; and can point to but few omissions, of which the same may be said, which speaks well for a book evidently compiled with some haste.

PRACTICAL TREATISE ON MINE ENGINEERING.—We have from time to time noticed the issue of the several parts of the second edition of the "Practical Treatise on Mine Engineering," by Mr. G. C. GREENWELL, F.G.S., and may now announce that the work, which is published by Messrs. Spon and Co., of Charing Cross, London, is completed. It was originally stated that it would consist of 16 half-crown parts, and this number has only been exceeded by one, so that for a couple of guineas the mining engineer and colliery viewer may possess himself of a really useful practical book, which, at the same time, will form a handsome ornament to his library. The work is divided into 9 chapters, embracing dissertations on the application of geology to mining; classes of rocks commonly met with in mining for salt, coal, and metallic ores; building materials; dykes, slips, and mineral veins; internal heat; metallic ores and minerals associated therewith, and with coal; smelting; boring and sinking tools; timbering; walling; tubbing; management of quicksands and clay; pumping engines and pumps; winding engines; ropes; pulleys; strength of timber, ropes, and other materials; the working of mines; underground haulage; working coal by machinery; copper; lead; tin; iron; salt; coal; ventilation; theory and practice; fire-damp; carbonic acid and other gases; explosions, and other casualties; and on various other matters of paramount importance to practical men. The basis of the work in its original form was a course of lectures delivered at the Newcastle-on-Tyne College of Practical Science in 1852, when mining institutes were unknown, and works upon the subjects treated of, at least in the English language, extremely scarce. The present edition is almost entirely re-written, yet the original character of the book has been retained. The author's object has been both to instruct the beginner in the art of mining, and to aid those who are more conversant with it in the execution of mining work. The changes which have taken place in the 16 years that have elapsed since the issue of the first edition have been great and important, and Mr. Greenwell, who has had the advantage of so much additional practical experience, has given his readers the full benefit of it, while supplying them with a record of the present position of mine engineering. The work is in every respect entitled to the patronage of mining engineers and mining students.

NOTES OF A COURSE OF SEVEN LECTURES ON ELECTRICAL PHENOMENA, AND ITS THEORIES, delivered at the Royal Institute of Great Britain. By JOHN TYNDALL, LL. D., F. R. S. London: Longmans, Green & Co. For sale by Van Nostrand. A brief summary, in 40 pages, of the history and present condition of Electrical Science. Invaluable to the scientific reader.

## MISCELLANEOUS

A CORRESPONDENT of "Engineering" writing from New York says:—

The Board of Commissioners of Docks, having in charge the newly created Department of Docks of New York, very properly tendered the office of Engineer-in-Chief of the department to General George B. McClellan, whose well-known skill and ability as an engineer and an officer marked him as pre-eminently the man for the posit on.

This enterprise in its magnitude is well represented, and will be satisfactorily managed under the superior engineering direction of General McClellan, who, in this, has in hand the most interesting practical engineering problem in the United States; the solution and execution of which will be looked for most anxiously by the engineers of both Continents

THE REPAIRED CABLE.—Mr. Weaver, General Manager of the Anglo-American Telegraph Company, writes to the London "Times," under date of August 19, as follows:

"The cable familiarly known as the 1866 cable, the property of this Company, which was broken in two places at about 41½ and 75 miles, respectively, from Heart's Content, Newfoundland, has been successfully repaired, and is now in perfect working order.

"The latter breakage having occurred near a spot where the cable had been damaged on two previous occasions, it was thought advisable to shift it, and this portion of the cable has been relaid in a safer position. It is hoped that this operation will prevent the recurrence of these accidents."

OUR means of estimating the illuminating power of coal gas are notoriously imperfect. Without going far into the question, we may say that the comparisons of the light with candles and

lamps are equally open to objection, although we seriously think that either mode, if the experiment be properly made, is satisfactory for all practical purposes. Nevertheless there are many who think that a better standard is desirable. Several years ago Erdmann proposed to estimate the value of gas by ascertaining how much air was required in combustion to destroy the illuminating power, and he invented an instrument known as "Erdmann's Gas Prover." In this instrument, however, no attempt to measure the quantity of air consumed was made, but was only inferred from the size of the aperture opened to admit it. It was suggested by Schilling that for the instrument to have any scientific value, meters and other apparatus must be added, so that the gas and air consumed might be accurately measured, and the combustion take place under the same conditions of pressure, etc.

Mr. Wilkinson, of Sheffield, has just made an interesting communication to the "Journal of Gas Lighting," in which he describes a mode of estimating the quality of gas by measuring the amount of air consumed, and expressing the value of gas in standard candles. We must refer our readers to the full article for a description of the apparatus and mode of making the experiment. We need only mention here that Mr. Wilkinson uses as a standard unit or measure 0.2 of air, or equivalent to one candle, and calculates his results accordingly. Thus, in the experiments he gives, 0.1 ft. of gas required 0.324 of air to take away the light; and $0.324 \times 5 = 16.20$ candles, which is assumed to be the illuminating power of the gas. Other experimenters will probably take up this mode of examination, and we shall have further information upon it. The point to be satisfactorily settled is the amount of air equivalent to a candle.—*Mechanics' Magazine.*

Deep-Sea Sounding.—In 7,706 fathoms, 36 deg. 49 minutes South Latitude, 37 deg. 6 minutes West Longitude, this sounding was obtained on a calm day, in the course of a passage from Rio de Janeiro to the Cape of Good Hope. The sounding-line was $\frac{1}{10}$ of an inch in diameter, laid into one length, and weighing, when dry, 1 lb. for every 100 fathoms. The plummet weighed 9 lbs., and was 11.5 in. in length, and 1.7 in. in diameter. When 7,706 fathoms had run off the reel, the sea bottom was reached. Captain Denham states that Lieut. Hutcheson and himself, in separate boats, with their own hands drew the plummet up 50 fathoms several times, and after it had renewed its descent, it stopped on each occasion, abruptly, at the original mark, to a fathom, and would not take another turn off the reel. The velocity with which the line ran out was as follows:

| | H. | M. | S. |
|---|---|---|---|
| The first 1,000 fathoms in..... | 0 | 27 | 15 |
| 1,000 to 2,000 " ..... | 0 | 39 | 40 |
| 2,000 to 3,000 " ..... | 0 | 48 | 10 |
| 3,000 to 4,000 " ..... | 1 | 13 | 39 |
| 4,000 to 5,000 " ..... | 1 | 27 | 6 |
| 5,000 to 6,000 " ..... | 1 | 45 | 25 |
| 6,000 to 7,000 " ..... | 1 | 49 | 15 |
| 7 000 to 7,706 " ..... | 1 | 14 | 15 |

The whole time, therefore, taken by the plummet in descending through 7,706 fathoms, or 7.7 geographical miles of 60 to the degree, was 9 hours 24 minutes, 45 seconds. The highest summits of the Himalay, Dhawalagiri, and Kinchinginga are little more than 28,000 ft., or 4.7 geographical miles above the sea. The sea-bottom has, therefore, depths greatly exceeding the elevation of the highest pinnacle above its surface. The strength of the line tried before the sounding, was found to be equal to bear 72 lbs. in air. The 7,706 fathoms which ran out, weighed, when dry, 77 lbs. exclusive of the plummet, 9 lbs. Great care was taken in the endeavor to bring the plummet again to the surface to show the nature of the bottom, but, whilst carefully reeling in, the line broke at 140 fathoms below the water-line, carrying away a Six's thermometer, which had been bent on at 3,000 fathoms.—*Electric Telegraph and Railway Review.*

Lead in America.—A white lead manufacturer in St. Louis, Mobile, has recently ordered from Europe 800 tons of lead, costing at that city, freight and duties paid, $7.35 per cwt., or $3\frac{1}{2}$ mills per lb. over the present prices of soft Missouri lead. It is claimed that the lead now mined in Missouri is filled with impurities, so as to be unfitted for the manufacture of white lead. Lead mining is also confined to persons of slender means, who sink shafts in search of crevice deposits, pockets, or float mineral, and success is a mere matter of chance. This kind of mining, it is asserted, has nearly exhausted the surface beds of Galena and other parts of Illinois, in Wisconsin, Iowa, Missouri, and Arkansas. While the production of lead in the West has fallen to 11,000 tons per annum, the consumption in the West alone has risen to 15,000 tons. The consumption of lead in the United States in 1869 amounted to 50,000 tons, of which 37,500 were imported. The freight of lead, it may be mentioned, is very low, in consequence of the desire of shipmasters to obtain ballast easily handled. Thus the freight upon lead from Europe to St. Louis, including handling at New Orleans and river transportation, is only 32 cents per 100 lbs., or less than the railway charges for lead brought from the mines in Northern Illinois. The freight to New Orleans is only 7 cents per 100 lbs.—*Iron Age.*

When copper has heretofore been detected in animal matters, its presence has always been regarded as accidental or fortuitous, and not as essential. Traces of the metal, it is true, have been found in some living animals, but these have doubtless been assimilated, as in the case of the oyster from copper salts, which have been carried in solution from mine drainings down to the mouths of rivers, without doing either good or injury to the animal. But in the turaco, or plantain-eater of the Cape of Good Hope, a bird celebrated for the remarkable beauty of its plumage, this metal plays, according to Professor Church, of England, a very important part. It is an essentiality in the composition of the red coloring matter of the bird's plumage, constituting about six per cent. of the same, and cannot be removed from it without a destruction of the matter; in effect, all the ordinary means fail to detect it without the pigment be first destroyed and the ash then examined for the metal. The existence of the red plumage is dependent upon copper, which, obtained in small quantities from the food, is stored up in this strange manner in the system of the animal, thus elaborating an element which is ordinarily regarded as poisonous to the animal economy, and which in this case seems to

serve the single purpose of decoration—an example to warn us against the fallacy of taking an entirely utilitarian view of the plan of creation.—*American Exchange and Review.*

INFLUENCE OF CANNON-FIRING UPON RAIN.—M. Charles La Maout, apothecary at Saint Brieuc, in France, has published some interesting observations on the influence of artillery-firing upon the fall of rain and the force of the wind. During the siege of Sebastopol, soon after the firing commenced the sky became obscured with clouds and a fine rain began to fall, which was sometimes followed by a deluge or whirlwind. Immediately, and as a consequence of the condensation, the mercury in the barometer rose in proportion to the violence of the cannonading. A chart of the movements of the barometer afforded a good indication of the bombardment. The author then proceeds to show how rain could be produced at will by a judicious discharge of artillery. There is no doubt that this would be a better use of cannon than the wholesale slaughtering of men, but whether rain could be produced at will in this way is another question. There is some confirmation of the theory in the fact that a violent rain fall has attended the recent engagement of troops near Metz, in France. The subject is one quite worthy of investigation, and if it were found to be expedient, the proposition of the author to establish meteorological stations with suitable artillery ought to be carried into execution.—*Journal of Applied Chemistry.*

CONDENSERS.—An invention of Mr. A. Barclay, Kilmarnock, relates to an arrangement of condensing apparatus, wherein an ejector is used in combination with a condensing chamber or vessel attached to cylinders of steam-engines or other receptacles wherein a vacuum or partial vacuum has to be formed. One passage of the ejector is attached to the lower part of the condensing chamber, and by means of it the injection water and water of condensation resulting from the steam or vapor in the chamber is drawn off. Another passage of the injector is connected with an opening at a higher level in the condensing chamber, and when the water in such chamber rises up to and above this opening, both water and air, and any uncondensed vapor that may be in the chamber, are drawn off by such opening until the water-level is reduced below the lower edge of the said orifice, after which air and uncondensed vapor only are drawn off through it.

ELECTRO-METALLURGY.—An invention of Mr. T. Chutaux, Paris, consists in keeping the solution constantly agitated by any suitable contrivance, and to operate this contrivance by the same electric battery which serves to apply the metals on the objects to be electro-plated. This is done by placing a revolving shaft, with a hellice at its lower end, vertically in the middle of the receptacle containing the solution. Its upper end, crossing a support composed of isolating material resting on the receptacle, is attached by an endless band passing over grooved pulleys to the shaft of a fly-wheel operated by a connecting-rod attached to an armature acted upon by the electro-magnet attached to the battery. The rotation given to the shaft is transmitted to the hellice, an ascending current is established in the middle of the receptacle, and a descending current towards its sides, in such a manner that all the parts of the objects operated upon are in a continual contact with a liquid of equal richness throughout, and the metal is thus deposited regularly and uniformly.

PROFESSOR GOULD has found that the velocity of the electric waves through the Atlantic cables is from 7,000 to 8,000 miles per second, and depends somewhat upon whether the circuit is formed by the two cables or by one cable and the earth. Telegraph wires upon poles in the air conduct the waves with a velocity a little more than double this ; and it is remarked, as a curious fact, that the rapidity of the transmission increases with the distance between the wire and the earth, or the height of the support. Wires buried in the earth likewise transmit slowly, like submarine cables. Wires upon poles, but slightly elevated, transmit signals with a velocity of 12,000 miles per second, while those at a considerable height give a velocity of 16,000 or 20,000 miles.

THE following estimate of the cost of war appears in "Cosmos" : The war in the East caused the death of 256,000 Russians, 107,000 French, 45,000 English, and 1,600 Italians. The Polish insurrection resulted in the death of 190,000, and the freeing of Greece 148,000. Africa has cost France somewhat about 146,000 men. The war in Italy was the cause of loss to the extent of 59,664 Austrian, 30,220 French, 23,610 Italian, 14,000 Neapolitan, and 2,370 Papal soldiers. Since 1815 Europe has lost 2,762,000 men on the field of battle. The Italian war cost 1,485,000,000 of francs. The war in the East cost Russia 2,328,000,000 francs ; France, 1,348,000,000 francs ; England, 1,320,000,000 francs ; Turkey, 1,060,000,000 francs ; and Austria, 470,000,000 francs.

A CUBIC inch of gold is worth (at £3 17s. 10½d. per ounce) £42 ; a cubic foot, £72,562 ; a cubic yard, £1,959,552. The amount of gold in existence at the commencement of the Christian era is estimated to be £85,400,000 ; at the period of the discovery of America, it had diminished to £11,400,000 ; after the occurrence of that event, it gradually increased, and in 1600 it attained to £21,000,000 ; in 1700, £70,000,000 ; in 1800, £225,000,000 ; in 1843, £400,000,000 ; in 1853 to £600,000,000 ; at the present time the amount of gold in existence is estimated to be £1,200,000,000, which, welded into one mass, could be contained in a cube of 26 ft. Of the amount now in existence, £800,000,000 are estimated to be in coin and bullion, £200,000 in watches, and the remainder in jewelry, plate, etc.

THE MANUFACTURE OF TAR PAVEMENT.—In most provincial towns there are two important bodies of men, the Paving Commissioners and the Gas Directors. The one is pledged to keep the rates low and the other to keep the price of gas as low as will enable them to provide the statutory dividend. As one means of insuring a cheap supply of gas is to create a greater demand and obtain a better price for the residual products, I have great pleasure in introducing a subject the adoption of which would be advantageous to both of these bodies. It is not a new one, but has hitherto been a neglected source of revenue to gas companies and will also be a great benefit to the public. That subject is tar pavement. In some counties, such as Yorkshire, where stone is as abundant as

brain is said to be, tar pavement will receive but little attention, but in the eastern and some other counties where the same conditions do not exist, but where York flag costs 7s. per yard laid, tar pavement is a desideratum. In such districts there is a scramble for pavement, and on account of the high price, unless a paving commissioner reside in the street, it remains unpaved. The foot passenger has thus to his great discomfort to walk on gravel or, as in Colchester, on stones laid in such a manner as would have done discredit to any of the Roman paviers who once resided in that neighborhood.

Tar pavement may be made of the ordinary cinder dirt produced in gas works of shingle or of a mixture of both. The material is burnt in heaps like ballast, and when hot is mixed with tar. In practice I make a small fire of coke on the ground and cover it with cinder dirt or shingle. When this layer is hot another is added, and so on in succession until a large enough heap has been provided. The tar is now boiled in an iron copper and taken when hot and mixed with the hot material from the heap already described, in quantities of two bushels at a time, in about the proportion of one gallon to every bushel of cinder dirt, and slightly less than a gallon for the gravel. It is turned over and over with the shovel until every part of the material has got a covering of tar. Then I pass the whole through a sieve with a $\frac{3}{4}$ in. mesh, and part of it through another with a $\frac{1}{4}$ in. mesh, and put the whole in heaps until required, as it may be kept for months before being laid down.

Before the pavement is laid, an edging should be provided about 2 in. thick, and projecting 2 in. above the surface of the ground to be covered, which should be tolerably even. It is advisable to have the ground next the curb well trodden on and rammed before the pavement is laid, otherwise there will be an unseemly hollow next the curb. In laying, the rough stuff is put down first and rolled tolerably firm, then the second quality is put on, then the third, and when the whole has been raked level a little of the finest material is sifted on through a sieve with $\frac{1}{4}$ in. meshes, and a little fine white shingle or Derbyshire spar is sprinkled on the top. The whole must now be well rolled. The best roller is a water ballast roller, which at first is used without ballast and well wetted to prevent adhesion of the material, and when the pavement is slightly consolidated the full weight should be applied.

For heavy cart traffic the material should be made of shingle only heated and mixed as above and well rolled. Both descriptions of pavement are laid best and most easily in warm weather, and should be rolled when the sun has warmed it well. Those parts in angles should be well rammed and trimmed off with a light shovel.

Though apparently a simple manufacture there is a little difficulty in ascertaining the proportion of tar to gravel or cinder dirt. A little experience will only be necessary in this as well as in all other manufactures, to enable any one to carry it out successfully.

I cannot recommend this pavement too much, as it is cheap, wears well, and can be easily repaired. The color, which never can be made to equal York flag, and the smell for some time after it is laid, are the only objections to its use; it can be laid with a good profit in any district at 1s. 4d. per square yard, and besides being a boon to the public, who must otherwise walk on the gravel, is a great advantage to gas companies. To them it provides a remunerative outlet for their tar, which often otherwise must be sold at a low price to distant distillers.

Since writing the above I have seen a paragraph in the "Times" which states that it is proposed to pave the streets of London with stone laid in asphalt instead of lime grout. This is just a more systematic application of the above described plan. For the tar by being boiled and thrown on hot stones becomes an elastic asphalt.

THE AILANTUS AS A TIMBER TREE.—Both in France and America this tree is said to be gaining ground in the estimation of practical men. Experiments made in France (says the "American Agriculturist") show the wood to have less density than that of the oak, and greater than that of the elm, while it is superior to either of the two in elasticity and tenacity. Ailantus planks have been exposed to the weather for 27 years, without shelter or paint, and the wood is still perfectly preserved. The wood is useful for agricultural implements, and it neither warps nor cracks. It saws readily, and afterwards acquires great hardness under exposure to the air. The ailantus grows so freely in America that it ought not to be a difficult matter to ascertain whether its timber is as serviceable there as it is said to be in France.

COCHINEAL, a common dyeing material, is often adulterated by being softened and swollen with steam, and then rolled about in sulphate of baryta, which gives the substance the appearance of a superior article. The fraud can, however, be readily detected, since, in the first place, the genuine article contains only from 4 to 6 per cent. of water, and this mode of adulteration increases that quantity to 11 per cent.; secondly, the quantity, as well as the quality, of the ash is entirely changed; 19.50 to 20 per cent. of sulphate of baryta has been found in the ashes of adulterated cochineal; the ashes, when no adulteration has been attempted, contain no traces of this salt.

AN observation has been made which has resulted in the discovery of a new mode of estimating the strength of alcohol. M. Ducaux has been experimenting on the superficial tension of liquids with an apparatus which exhibits the variations of it in a very remarkable way. A dropping tube, for instance, is arranged to let fall in air 100 drops a minute. If, now, the experiment be repeated in air saturated with vapor of alcohol, instead of 100 drops 110 will fall in the minute. This is caused by the solution of some alcohol in the water, by which the superficial tension of this liquid is diminished. Further experiments led to the discovery that the strength of alcohol could be exactly determined by ascertaining how many drops would fall in a minute from a given orifice.

BLAST ENGINES.—An invention of Mr. W. Neill, Jun., Bold, Lancashire, consists in the use of slide valves to prevent the air which has been compressed from escaping at the outlet. For this purpose the inventor employs apparatus whereby the air passages are closed when the piston arrives at the end of its stroke, and by which the said valves are so held until a portion of the return stroke has been effected, after which the inlet and outlet passages are fully opened.